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Space Politics

An Evolutionary

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SPACE POLITICS AND POLICY

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SPACE POLITICS AND POLICY

An Evolutionary Perspective

Edited by

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ACKNOWLEDGEMENTS

The genesis of this book began back in 1997 when I recognized a need for establishing a conceptual framework by which to understand and explain Space Policy. To this end I took the initiative to make that a reality, which is this book. The beginning of this book project took place at a Space Politics and Policy Workshop held at NASA Headquarters in Washington DC in 1998 among all the contributing authors. This workshop was sponsored by a grant from the Institute for National Security Studies of the United States Air Force Academy, which I am grateful for and in which Peter L. Hays played an important role in securing, and supported logistically by the NASA History Office and in particular Roger D. Launius, who provided at the onset much needed philosophical guidance and moral support for the book.

In the course of the four years following this workshop, I received the chapters from the contributing authors and undertook the extensive job of editing and finishing to write my own chapters in the book. As the contributing authors will recognize, I took a more hands-on approach to the editing task and hence, many chapters have additional material and insights that I feel make the book more cohesive. I guess this is the editor's challenge as well as prerogative. As such, I retain responsibility for any errors of fact and judgment or misconstrued insights.

I would like to thank all contributing authors- Willy Z. Sadeh, Roger D. Launius, Roger Handberg, Christopher J. Bosso, W. D. Kay, Linda T. Krug, Joan Johnson-Freese, Howard E. McCurdy, James P. Lester, Nathan C. Goldman, Molly K. Macauley, James A. Vedda, David M. Livingston, Stephen B. Johnson, Xavier Pasco, Laurence Jourdain, Peter L. Hays, Dwayne A. Day, and John M. Logsdon. The expertise and insights into Space Policy provided by the contributing authors are reflected here in the pages of this book.

Of the contributing authors, the late James P. Lester, my Ph.D. adviser from 1995 to 1999, was instrumental in helping me to develop the concept and framework for the book, and Peter L. Hays made sure that the national security parts of the space program were properly accounted for. Also, I need to thank the Department of Space Studies at the University of North Dakota, where I currently serve as Assistant Professor of Space Studies, for logistical support, and my graduate research assistant in the Department, Trent Benisch, for his help in editing some of the Tables and Figures and in helping me to complete the research for the book.

Lastly, my late father, Willy Z. Sadeh, is the one who inspired me to always challenge the impossible and instilled in me that space is representative of that challenge. It is due to his inspiration foremost that I developed the idea for this book and made this book a reality.

Eligar Sadeh, 31 May 2002

PROLOGUE
HUMAN SPACE EXPLORATION: A MYTH OR A MUST

Willy Z. Sadeh (1932-1997)*

One of the major questions to be answered in this time of profound change is whether space exploration is a myth or a must as humankind enters the twenty-first century. Historically, the space age started about forty years ago in the mid 1950s with both American and Soviet plans to conduct satellite observations during the 1957-58 International Geophysical Year. The first two milestones of the space age were the orbiting of artificial Earth satellites, Sputnik in October 1957 and the American Explorer four months later in January 1958.

The establishment of NASA in July 1958 laid the foundations of the United States civil space program that are still effective today and undoubtedly will be in the future. Subsequent milestones were the first manned flights in space by Soviet cosmonaut Yuri Gagarin in April 1961, followed by American astronaut Alan B. Shepherd in May 1961. The landmark achievement of the space age to date was the Apollo 11 mission that landed Neil Armstrong and Buzz Aldrin, the first men on the Moon, on 20 July 1969. Over a period of eleven years, 1958 to 1969, engineering evolved from launching small satellites to Saturn V boosters capable of sending humans on a voyage to the Moon. The launch of Skylab in the 1970s, the Soyuz, the Space Shuttle, the Space Station Mir, and the International Space Station represent the first steps toward the settlement of the space frontier.

Earth is the only planet within the Solar System that we know of that sustains life. Why does life exist on Earth and does life exist on other planets such as Mars? A question of even greater significance is whether other planetary systems that sustain life exist within other solar systems. These questions touch on our very existence as a life form.

Exploration and discovery are the driving forces behind human existence. The moment we stop exploring, we cease being human beings. From the day we are born we explore. First, we explore our immediate environment and next the entire world. Exploration depends upon the availability of technology required to support it; explorers of the fifteenth and sixteenth centuries, Christopher Columbus, Americo Vespucci, Vasco de Gama, and Ferdinand Magellan were able to sail the oceans and open the gates of the Americas and beyond because navigation and shipbuilding technology allowed them to do so. The Wright Brother's powered flight at Kitty Hawk nearly one hundred years ago (in December 1903) laid the

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* Former Professor of Space Engineering, Colorado State University.

foundations for aeronautical technology that provided the first transpacific service by the 1930s and eventual air exploration of the world.

A combination of vision, political commitment, funding, and technology governs the open-ended avenue of human space exploration. The vision is here; space exploration has been the dream of humankind since ancient times. Today, the technology required for space exploration is available. Political commitment and allocation of funds are needed. Human space exploration beyond the International Space Station starts with a permanently human-tended base on the Moon followed by human exploration of Mars. Together with this exploration goes exploitation of space resources for the benefit of humankind. This includes both global observation of the Earth to control our own environment and the import of "limitless" resources from space.

When Columbus opened the gates to the European settlement of the Americas more than 500 hundred years ago, nobody could predict that today we would have a United States of America. Now we are on the verge of starting the human exploration of the space frontier and becoming a spacefaring civilization. Can we predict how the world, or for that matter outer space, will look five centuries from now?

The human spirit of exploration cannot be stopped; at most it can be momentarily slowed down by political and budgetary constraints. It is these constraints that are examined in this important book, *Space Politics and Policy: An Evolutionary Perspective.* Any civilization that does not challenge the impossible is doomed to fail. And, the impossible for our civilization is the human settlement of the infinite space frontier.

INTRODUCTION

SPACE POLITICS AND POLICY: AN EVOLUTIONARY PERSPECTIVE

Eligar Sadeh*

> "The lesson to me seems clear: there may be no way to send humans to Mars [or back to the Moon] in the comparatively near future, despite the fact that it is entirely within our technological capability. Governments do not spend vast sums just for science, or merely to explore. They need another purpose, and it must make real political sense."
>
> *Carl Sagan*

In his recent book, *Pale Blue Dot,* the late professor and astronomer Carl Sagan makes the case that political forces will largely dictate the future of the space program. Nevertheless, space policy as a subject matter for research and teaching has not received the attention of the academic community in a significant way. More generally, space studies education has not been accepted by national educational systems to any great extent despite the enormous wealth of new knowledge it offers.

Yet, space may become one of the most important public policy issues in the twenty-first century. With the recent discovery of possible microbial life forms on Mars and the intriguing possibility of life elsewhere, such as on Europa and Titan, the prospect of ecological collapse in many parts of the world due to global change processes, the enormous natural resource wealth that space offers, and even the probability of Earth being hit by an asteroid, serious attention to space exploration and development of space is justified. Indeed, according to Carl Sagan, it is an imperative for "species survival" and human evolution.

A space studies education is an important component of our knowledge base that provides the means for better choices about how to utilize the space environment for human benefit. Given that exploring and developing space "must make real political sense," understanding and explaining the "crucial political variables," such as historical conditions, political processes and policy outcomes, organizational and administrative

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* Professor of Space Studies, University of North Dakota

factors, economic and legal aspects, and scientific and technological forces, which determine space policy now and in the future, is important for students and decision-makers of space policy. Political scientists, historians, economists, lawyers, sociologists, philosophers and others have much to offer in terms of increasing our understanding of space policy. Moreover, space, as an issue for national and foreign policy, will only become more salient as the twenty-first century progresses.

AN EVOLUTIONARY PERSPECTIVE

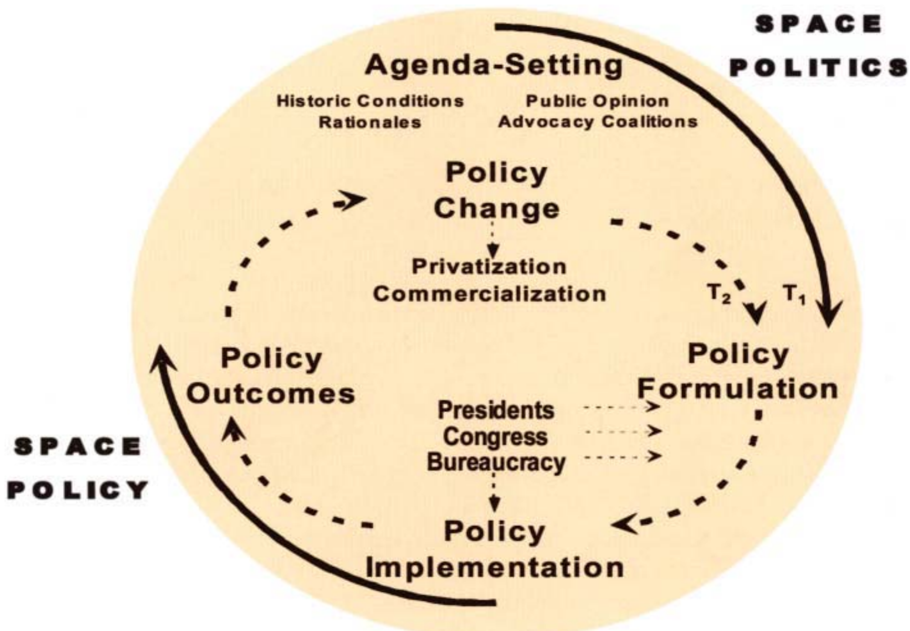
The goal of *Space Politics and Policy: An Evolutionary Perspective* is to provide an overview and primer for the field of space policy. This book is organized around two themes: (1) space policy is evolutionary in that it has responded to dramatic political events, such as the launching of Sputnik and the Cold War, and has undergone dynamic and evolutionary policy changes over the course of the space age; and (2) space policy is an integral part of and interacts with public policy processes in the United States and abroad.

The book analyzes space policy at several levels of analysis including historical context, political actors and institutions, political processes and policy outcomes; examines the symbiotic relationships between policy, technology, and science; provides a review and synthesis of the existing body of knowledge in space policy; and identifies space policy trends and developments from the beginnings of the space age through the current era of the twenty-first century.

The "Space Politics and Policy Framework" shown below was developed to represent the evolutionary perspective of space policy. This framework serves as the basic organizing and conceptual scheme for this book. Space Policy involves both the process (Space Politics) of policy formation and policy change over time, and the courses of action taken to achieve political and technological determined outcomes (Space Policy). Space Politics involves the process by which historic conditions, rationales for space, and advocacy coalitions interact with and impact agenda-setting; actors and institutions (Presidents, Congress, and the space bureaucracy) interact with and impact public policy formulation and implementation; and how policy outcomes bring about policy change (emergence of privatization and commercialization). Space Policy deals with the outcomes that include such areas as the environment, law, commerce, international cooperation, and national security.

The evolution of Space Policy over time takes place through policy change. On this basis, public policy processes over the course of the space age, represented by T_1 in the Framework, have involved the mobilization of governmental resources, actors, and institutions. Concomitantly, nongovernmental actors, such as private corporations and commercial enterprises, increasingly play a role in developing space. T_2 in

the Framework denotes this evolution in Space Policy. As a result, market factors in addition to political forces influence Space Policy. This book is divided into three parts and a conclusion each of which address an aspect of the Space Politics and Policy Framework.



Space Politics and Policy Framework
(source: compiled by Eligar Sadeh)

PART I.
SPACE POLICY AGENDA-SETTING: HISTORICAL CONTEXT

Part I of this book examines the agenda-setting phase, which is largely the historical context under which space policies emerge. Agenda-setting is the political process of political legitimacy and feasibility. Legitimacy is a matter of issue recognition that occurs as a result of historic conditions that present a crisis or focusing event. Feasibility deals with how the policy issue is adopted and ultimately moved to the point of decision-making. Policy adoption is determined by the legitimacy of the rationale factors supporting space exploration and development of space activities. Lastly, the decision-making calculus– moving the political issue from agenda-setting to actual policy formulation such as in presidential decisions, congressional legislation, and public law– is influenced by advocacy coalitions.

The first chapter in this part, Historical Dimensions of the Space Age, provides an overview of the historical conditions and themes underlying the context wherein space politics and policy takes place. Chapter 2, Rationales of the Space Program, explores how the legitimacy and feasibility of space activities are shaped by the way in which the space program is justified. The third chapter, Advocacy Coalitions and Space Policy, examines how space-related advocacy groups play roles in the political process.

PART II.
SPACE POLICY FORMULATION AND IMPLEMENTATION: ACTORS AND INSTITUTIONS

Part II of this book focuses on the political actors and institutions, and how they engender space policy formulation and implementation. Policy formulation is where acceptable courses of action for dealing with some particular problem are identified and enacted into public law or policy decisions. An underlying theme is that the space politics is one of coalition building that involves a plurality of political actors that include the President, Congress, the space bureaucracy, advocacy coalitions, and commercial enterprises. Formulation, by its very nature, reflects many views, perspectives, and interests, and thus, involves a process of political accommodation leading to goal modification.

In other words, the political process of formulation represents a compromise between what a space organization (like NASA) may want and might regard as most effective, efficient, or feasible, and what it perceives as the appropriate response to political forces. The political forces are shaped by the historical conditions. Policy formulation, in turn, is framed by the extent to which formulated policies are congruent with the rationale factors. The chapters on Presidents and Space Policy and Congress and Space Policy probe into this process of policy formulation. These chapters discuss how both the President and Congress essentially work, at times through conflict and at other times through cooperation, to co-determine space policy in the formulation stage.

Policy implementation involves the development of the enabling space technologies and their application to the actual building of the hardware and systems to support space related projects and programs; it is "rocket science." Clearly, technical ability and know-how are important variables affecting implementation. However, the technical skills of the implementers, such as national space agencies and commercial industries, are influenced by bureaucratic and associated economic issues as well as by the inherent organizational issues involved with developing and then administering complex space technologies. The chapters on Bureaucracy and the Space Program and Public Administration of the Space Program assess how political, bureaucratic, organizational, and administrative forces all play roles

that can either enable or constant how the space implementers go about their business of rocket science.

PART III.
SPACE POLICY OUTCOMES

Formulation and implementation lead to specific policy outcomes. The outcome areas explored in this book include the environment, law, commerce, cooperation, and national security. Space and the environment are inextricably linked through the use of space to assess global environmental change here on Earth. The Space and the Environment chapter examines the policy issues related to Earth observations from space, and then proceeds to address the environmental and ethical concerns related to space exploration activities. Space law has played an essential role in ensuring the free and peaceful use of space. The Space Law chapter looks at the evolution of space law since Sputnik and assesses the current issues and status of space law. Space commence is recognized as the fundamental policy change of the space program. As a whole, the chapters on Economics of Space, Space Commerce, Space Business, and Ethics and Off-Earth Commerce provide a thorough examination of the economic, commercial, business, and even ethical issues of space commercialization. With the end of the Cold War, international cooperation, rather than international conflict, has emerged as a major driving force for advancing government and commercial space programs. The evolution and dynamics of space cooperation are evaluated in the chapter on International Space Cooperation. Albeit this book focuses on the United States (US) space program, there exist other significant space programs. The chapter on Comparative Space Policy compares the evolutionary trajectory of the US program in relation to the European and French space programs.

Finally, it is essential to understand that the government-based civil space program is just one of several space programs. These other programs include the commercial one, which is examined in the chapters dealing with economics, commerce, and business, the military space program, and the intelligence space program. The evolution and policy issues related to these latter two programs are reviewed in the chapters on Space and the Military and Intelligence Space Program.

SPACE POLICY CHANGE

Space policy change is a theme that is prevalent throughout the book and is reflective of the “evolutionary perspective.” The concluding chapter to this book encapsulates the evolution of space policy from the Apollo era to the present. Of importance, is how the evolution has made space policy part and parcel of the political discourse on public policy, whether directed

for furthering governmental or commercial ends. In this regard, outer space, as this book indicates, has evolved from the "extraordinary" to the "ordinary." Visions of a spacefaring future where humanity settles the Solar System still captivate the imagination, but as an issue of policy space is pervasive in advancing important utilitarian undertakings.

PART ONE

SPACE POLICY AGENDA-SETTING:

HISTORICAL CONTEXT

1
HISTORICAL DIMENSIONS OF THE SPACE AGE

Roger D. Launius*†

INTRODUCTION

It is a common understanding that the space exploration program of the United States (US) was born out of the Cold War rivalry between the US and the Soviet Union in the latter 1950s. Further it is also banal to say that with the birth of the space age in 1957, the efforts to explore this new region have progressed along a rather rocky path from a cautious beginning through anxious implementation back to cautious activities at the end of the twentieth century and beginning of the twenty-first century. Engaged in a broad contest over the ideologies and allegiances of the non-aligned nations of the world, space exploration enjoyed for more than a decade a treasured place in the pantheon of American public policy initiatives, and the scientific and technical elites comprising the institutions carrying out those initiatives received favored status and preferential treatment in the scramble for resources. Such priority lessened in the 1970s, and with the collapse of the Cold War continued emphasis on spaceflight has lessened as well.

This chapter examines the historiography of space exploration and the nature of the themes explored in the field since the dawn of the space age more than forty years ago. There are several distinct perspectives to the historical dimensions of the space age. The first is the historiography of expectation. This history includes not only the so-called "Huntsville School" of writing but also those fascinated with the machinery and those who use history to promulgate the space exploration agenda for the future. The second perspective is a distinctly different type of historical analysis, the exposé. This analysis explores history not to further some peculiar agenda, but for the illumination it provides individuals in shaping the course to future trends and developments in space exploration.

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*Division of Space History, Smithsonian Institution. Former NASA Chief Historian, NASA History Office.

†An earlier version of this chapter appeared as an article in *Space Policy 16 (2000).*

TYPOLOGY FOR SPACE EXPLORATION STUDIES

In some respects, this chapter identifies a "New Aerospace History." This approach represents a significant transformation that has been taking place in the field of History since the 1980s. The "New Aerospace History" is intrinsically committed to relating the subject to larger issues of society, politics, and culture, taking a more sophisticated view of the science, technology, and individual projects than historians previously held. In the past, many writers on aerospace history held a fascination with the machinery, which has been largely anthropomorphized.[1]

The "New Aerospace History" moves beyond a fetish for the artifact to emphasize the broader role of the spacecraft, and more importantly the whole technological system including not just the vehicle, but also the other components that make up the aerospace technology, as an integral part of the human experience. It is an affirmation that one moves through reason and study to a larger understanding. This assumption is based on an understanding of humans, for technological systems as constructions of the human mind.

Critiques of the reification of the artifact in aerospace history have largely fallen on deaf ears in the past. Perhaps the influence of buffs is too strong; perhaps some extraordinary features of the technology seduce staid historians so that they "go native" and lose perspective on the human and social forces that are the true essence of technology. Possibly, because of this, most of the sophisticated work done in the history of space exploration to date has come from outside of history. Mostly political scientists have addressed the one part of aerospace history that has received sustained, repeated, high-quality treatment, the political decisions to create NASA and race the Soviet Union to the Moon. In the more restricted topics of the history of aerospace technology and space science, much of the strongest theoretically motivated work is by more general historians of science or technology.[2]

This "New Aerospace History" emphasizes research in aerospace topics that are no longer limited to the vehicle-centered, project-focused, scientific-internalist style of space history. Many of the recommendations that historian James R. Hansen suggested in a historiographical article in *Technology and Culture* are coming to fruition.[3] Taken altogether, these tentative explorations of themes build on what has gone before. They represent a departure from the simplistic works that preceded them, notably the argumentative volumes and essays that either espouse or ridicule space exploration. These polemics, of course, exist side by side with the "New Aerospace History." This work is of a scholarly nature, but more often than not it has been of a popular vein, and the intention has been toward the

presentation of legal briefs, using history as a proof-text for convincing unbelievers, than honest historical inquiry.

In the center are the practitioners of the "New Aerospace History," professionally trained scholars of differing ideologies and prerogatives who concentrate on questions other than whether or not space exploration is justifiable. This "center" is a position between those detractors who argue that the journey into space is without legitimacy and those advocators who insist on continuation and expansion of space exploration. While the center of the historiographical spectrum seems to be gaining credence and sophistication, representatives of both the detractors and advocators remain present in the historical literature.

HISTORY AS ADVOCACY: THE HUNTSVILLE SCHOOL

The best example of the use of history to advocate an aggressive space exploration agenda has been the effort that Rip Bulkeley christened the "Huntsville School," so named because of where it originated. Wernher von Braun, his confidants, and his followers for years dominated the study of space history and their perspectives are still very present on the historiographical landscape. Von Braun's most significant contribution to this writing was the massive illustrated *History of Rocketry and Space Travel,* which went through three editions by 1986, and has been influential in shaping popular conceptions about spaceflight.[4] In particular, von Braun associates Ernst Stuhlinger, Walter Dornberger, Frederick C. Durant III, Frederick I. Ordway III, and Mitchell R. Sharpe extended the approach pioneered by von Braun in their historical writings about space exploration.[5] Also, a younger generation of historical writers promulgated the message of the "Huntsville School."[6]

In every case, there are several key ingredients in the work produced by the Huntsville School of space historiography. One ingredient is that the German rocketeers who built the V-2 and then came to America at the end of World War II emerged as far-sighted visionaries with an integrated space exploration plan that would foster a future of great discovery in the "final frontier." Von Braun's plan for aggressive space exploration advocated building Earth-orbiting, piloted spacecraft and a space station; undertaking human expeditions to the Moon, preceded by robots; sending robots to Venus and Mars; and dispatching human expeditions to the nearby planets in the inner Solar System. This "von Braun paradigm" of space exploration, illustrated in Figure 1.1 on page8, is central both to the historical

understanding of space historiography and to the space policy planning process throughout the twentieth and twenty-first centuries.

The Huntsville School minimized its wartime cooperation with the Nazi regime in Germany and maximized the team's role in the development of American rocketry and space exploration. Both were conscious distortions of the historical record disseminated for specific personal and political reasons. Even today, few Americans realize that von Braun had been a member of the Nazi party and an officer in the SS and that the V-2 was constructed using slave labor from concentration camps. They also do not understand that the US had developed a very capable rocket technology in such places as the Jet Propulsion Laboratory (JPL), in the Air Force, and at several private corporations. The result has been both a whitewashing of the less savory aspects of the careers of the German rocketeers and an overemphasis on their influence in American rocketry.

Others unassociated with the Huntsville School have also used historical studies for their own purposes. Notably, some have used the historical analogy of the American frontier and the space frontier to advocate funding for an aggressive spaceflight program. Indeed, the metaphor proved remarkably apt as a description of American mindset and will. It conjured up an image of self-reliant Americans moving westward in sweeping waves of discovery, exploration, conquest, and settlement of an untamed wilderness. And in the process of movement, the Europeans who settled North America became an indigenous American people.

The frontier ideal has always carried with it the ideals of optimism, democracy, and righteous relationships. It has been almost utopian in its expression, and it should come as no surprise that those people seeking to create perfect societies in the seventeenth, eighteenth, and nineteenth centuries the Puritans, the Shakers, the Moravians, the Icarians, the Mormons, and others often went to the frontier to carry out their end. John Glenn captured some of this tenor in 1983 when he used the American heritage of pioneering and argued that the next great frontier challenge was in space: "[space] represents the modern frontier for national adventure. Our spirit as a nation is reflected in our willingness to explore the unknown for the benefit of all humanity, and space is a prime medium in which to test our mettle."[7]

President John F. Kennedy, an able user of the American past to promote his political vision, was one of the earliest and most persistent users of this metaphor. Kennedy defended an aggressive exploration of space: "[space] is one of the great adventures of all time, and no nation which expects to be the leader of other nations can expect to stay behind." He harkened back to the American frontier in speaking of what might be gained in the unknown of space. But more important, he called upon the adventurousness of the American people and offered the promise of an almost

utopian change in society as it moved to a new, untainted place where it could remake society. Such has always been the siren call of the frontier.[8]

Without question, however, the NASA leadership is the most persistent exponent of the frontier metaphor as a justification for the space program. Wernher von Braun, the single most important promoter of America's space effort in the 1950s and 1960s, captured the western myth and used it to justify the space program. Although a German immigrant to the US after World War II, he was remarkable in his grasp of what made Americans tick. He spoke often of "The Challenge of the Century" as a continuation of American exploration and settlement. "For more than 400 years the history of this nation has been crammed with adventure and excitement and marked by expansion," he said. "Compared with Europe, Africa, and Asia, America was the New World. Its pioneer settlers were daring, energetic, and self-reliant. They were challenged by the promise of unexplored and unsettled territory, and stimulated by the urge to conquer these vast new frontiers."[9]

Albeit the frontier ideal is a powerful motivating force, it is at best an inaccurate historical analogy. Western historian Patricia Nelson Limerick, for one, has argued that the frontier concept used as a metaphor by many in the space community, should be seen as a pejorative reflection. Limerick argued that it denotes conquest of place and peoples, exploitation without environmental concern, wastefulness, political corruption, executive misbehavior, shoddy construction, brutal labor relations, and financial inefficiency.[10] Despite this reality, many of those writing space history continue to use the metaphor in their analysis.[11] There are also those who are mesmerized by space technology and thus, write "nuts and bolts" history without much attention to the wider questions that influenced the effort. Many of these are aerospace engineers and their work is often pedantic, sophomoric, and celebratory. One example of works in this genre are those relating to the history of the Space Shuttle, a subject for which there is still no adequate scholarly history despite the fact that the project was approved by President Nixon in 1972. While works on this subject stand out for a popular audience based on the serious attention to technical detail, all are essentially non-critical and non-scholarly.[12]

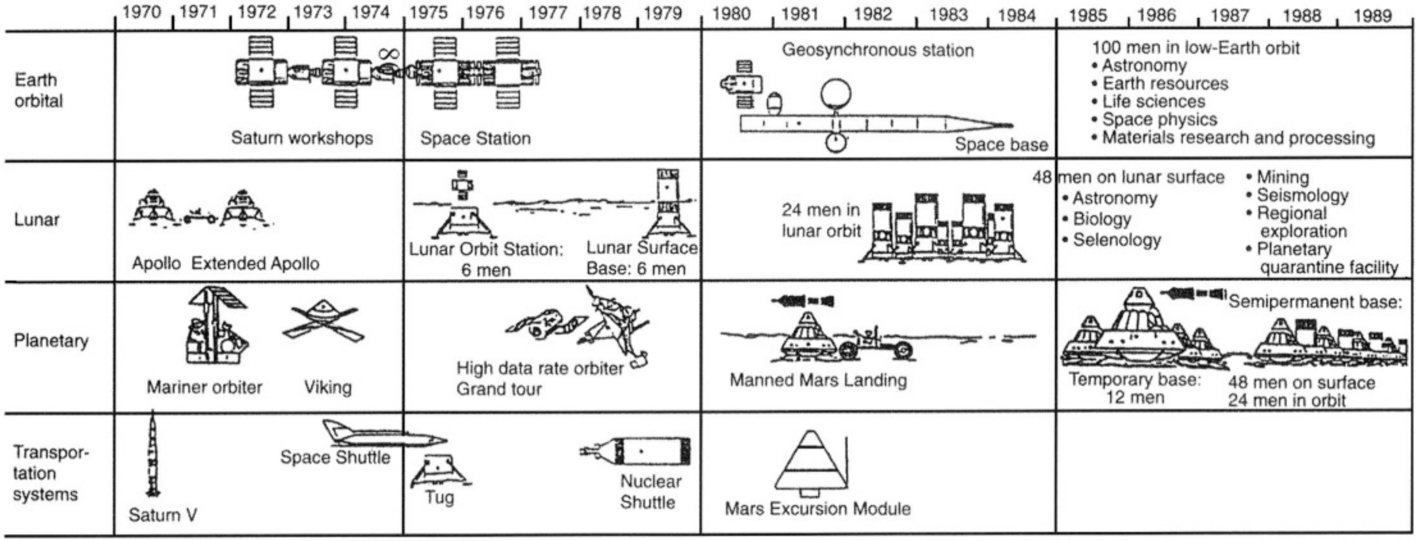

Figure 1.1. Paradigm of Space Exploration.

Note: Wernher von Braun put forward plans for a space exploration program starting in the early 1960s. Von Braun on behalf of NASA presented this integrated space program after the first manned landing on the lunar surface.

Source: NASA History Office.

SPACE EXPLORATION AND HISTORICAL SKEPTICISM

Just as important as those who use history to celebrate space exploration and its elements, there are those who use it to attack the whole enterprise. Some of these attacks are sophisticated and involved, others are simplistic and without appeal to all but those with the predilection to believe them.

As might be expected, several of these critical historical analyses have emerged in the aftermath of major accidents, especially the Apollo 204 capsule fire in 1967 and the Space Shuttle Challenger accident in 1986. In 1968 Erik Bergaust published one of the earliest critical accounts of the Apollo 204 accident in January 1967 that killed astronauts Gus Grissom, Roger Chaffee, and Edward White. Bergaust took issue with NASA's design approach that allowed for the use of a pure oxygen atmosphere in the Apollo command module. In a largely jingoistic account, Bergaust concludes that the human and fiscal sacrifices made in Project Apollo have been in vain, since the Soviet Union (seen as the reason for Apollo) did not seem to be going to the Moon at all.[13] Likewise, in an examination by Erland A. Kennan and Edmund H. Harvey, Jr., the authors conclude:

> The real reasons for the [Apollo] tragedy were a lack of perspective and flexibility within NASA management at all key levels; inept, competing, or nonexistent channels of communication throughout the organization's many facilities; lazy, sloppy, and unduly profit-motivated contractor performance, myopic congressional indulgence (often referred to as "Moon-doggling"), irresponsible public relations to the point where NASA actually believed its own inflated propaganda; and finally, a remarkable aloofness from and disdain for the legitimate interests of the taxpaying American public.[14]

Two books also stand out as exposes of the Challenger accident. The first, by Malcolm McConnell, investigated the immediate causes of the accident and roundly criticized NASA management.[15] McConnell highlighted the pressures to launch, the objections of engineers, and the internal debates on the subject, and argued that NASA leaders caused the disaster by pressing operations officials to launch when they did so that the President could mention it in that evening's State of the Union Address. Another book on this topic, written by Joseph J. Trento and Susan B. Trento, is a sweeping denunciation of NASA management in the post-Challenger era that emphasized the agency's putative "fall from grace" after Apollo. They argued that the giants of the 1960s, the people who had successfully managed

the Apollo program, were gone and had been replaced with government bureaucrats who played the political game and sold the Space Shuttle as an inexpensive program, in the process sowing the seeds of disaster. The Trentos blamed the Nixon Administration for politicizing and militarizing the space program. Every NASA Administrator since that time, they said, has had to play hard, but against bigger opponents, in both arenas. They argued that the failure was not caused by the space vehicle's O-rings that allowed the explosion of the Space Shuttle, but by the political system that produced them.[16]

In addition, periodic broadsides have emerged from diverse quarters almost from the beginning of space exploration. For instance, journalists Hugh Young, Brian Silcock, and Peter Dunn published in 1970 a ponderous "anti-Apollo" attack. Their work characterizes Wernher von Braun as a self-righteous traitor and John F. Kennedy as an adolescent exhibitionist. They describe a conspiracy of bureaucrats, industrialists, and politicians who promote space as a means of feathering their own nests.[17] More recently such historical writers as Greg Easterbrook, T.A. Heppenheimer, and Alex Roland have written pointed critiques of NASA and space efforts using historical information as the basis for their cases.[18]

These criticisms require reasoned consideration in the study of space exploration's history. However, they often abandon one of the most cherished principles of historical scholarship, the "shibboleth of objectivity." Called "that noble dream" by Charles Beard and others, the quest for objectivity has motivated historians above all else for most of the twentieth century. The fundamental philosophical thrust of recent historical inquiry has been a blurring of the line between fact and fiction, between history and poetry, between the unrecoverable past and our memory of it, between reporting and opinion.[19] According to Robert F. Berkhofer, the philosophy of history presently in vogue essentially denies factuality. He claims that the "transmutation of so much– some would say all– of the referential side of history into the presentational and narrative side destroys the effect of overall factual authority claimed for historical productions."[20] Hayden White, a leader in this field, argues that historical writing is not simply noting "facts" in a chronological sequence and allowing a theme to emerge, it involves consciously fashioning a story, an "emplotment" in White's jargon, that achieves coherence only through the decryptions and glossing of the historian. Hence, White stresses the imaginative and literary aspect of all historical writing, in the process largely rejecting the necessity of maintaining a touchstone to the unrecoverable past through documentary sources.[21]

Such studies raise the specter of the inexact character of historical "truth," and of its relationship to the study of space exploration. On both extremes of the continuum of historical study about spaceflight, it is important

to test hypotheses and not to dismiss the works out of hand. Critical analyses of such claims are mandatory. While both defenders and critics of space exploration have developed important arguments, they do not represent the mainstream of historical study; their perspectives only inform, rather than drive, the insights developed in the historical scholarship being produced that seeks objectivity.

CENTER OF HISTORICAL INQUIRY

In the center of the historiographical spectrum concerning space exploration are those historians whose interests do not include either the affirmation or denial of the legitimacy of the endeavor.[22] There has been a large increase in the number of individuals concentrating on the history of the space exploration in this category in recent years. They have a variety of perspectives, ranging from those very positive toward the effort to those critical of policies, conduct, and personnel. They are unified, however, by a common goal to understand the history of space exploration and to analyze its development without regard to proving or disproving its legitimacy. For instance, the work of John Logsdon is highly supportive of the activity, while the single historical book on the subject by Walter McDougall is quite critical of large-scale technological enterprise such as Project Apollo. Even though these authors are firmly in the center of the broad historiographical spectrum and are "New Aerospace Historians," their works exhibit remarkably differing sets of priorities, interests, and approaches.

The "New Aerospace" historiography came of age with the 1985 publication of McDougall's Pulitzer Prize-winning book, *...the Heavens and the Earth: A Political History of the Space Age,* on the origins and conduct of the space race.[23] McDougall's book analyzes the Cold War rivalry in race with the preparations for and launch of Sputnik 1 on 4 October 1957 through the race to the Moon in the 1960s. The author argues that the mandate to complete Apollo on Kennedy's schedule prompted the space program to become identified almost exclusively with high profile and expensive human spaceflight projects. This was so because Apollo became a race against the Soviet Union for recognition as the world leader in science and technology. McDougall juxtaposes the American effort of Apollo with the Soviet space program and the dreams of such designers as Sergei P. Korolev to land a Soviet cosmonaut on the Moon. The author recognizes Apollo as a significant engineering achievement, but concludes that it was costly both in terms of resources and the direction to be taken in the state's support of science and technology. In the end, NASA had to stress engineering over science,

competition over cooperation, civilian over military management, and international prestige over practical applications. Not all agree with all of McDougall's historical arguments, but since the publication of *...the Heavens and the Earth* historians have been striving to equal its analysis, writing, and scope of discussion.

While few have matched McDougall's success, the "New Aerospace History" is a burgeoning field and representative examples of superior work abound. The following major subjects represent the historical dimensions of this Aerospace History.

> *Origins of the Space Age* (a discussion of early rocketry and the ICBM programs as well as international scientific efforts in the 1950s, culminating with the creation of NASA in response to the Sputnik crisis).
>
> *Civil/Military Relations in Space* (this relates not just to "two sides of the same coin" origins of spaceflight, but also to the continuing probable relationship of the two in the context of such Presidents as Reagan proposing both the Strategic Defense Initiative (SDI) and Space Station Freedom as an integrated effort to best the Soviet Union).
>
> *National Sovereignty in Space Exploration* (others will equate this to international competition and cooperation, but by moving beyond the stereotypes of Cold War rivalries there is an enormous potential for additional understanding).
>
> *Politics of Space Exploration* (how space expenditures seem driven in more instances than many other domestic programs by political objectives that bear little relationship to the space projects undertaken).
>
> *Spaceflight and its Technological Legacy* (the hardware and its evolution).
>
> *Space Science and Understanding of the Universe* (scientific efforts from Vanguard to Mars exploration).
>
> *Human Imperative in Space Exploration* (perhaps this could be titled "megabucks" for a few Buck Rogers).

Making Life on Earth Better (dividends from space ranging from instantaneous global telecommunications to remote sensing to new perspectives on the environment).

Space and Popular Culture (brief discussion of popular conceptions of spaceflight and its ramifications for public policy).

Origins of the Space Age

There have been several works published since 1990 concerning the origins of the space age.[24] Collectively, these works have filled in the gaps about what took place in the 1950s concerning the exploration of space, especially taking advantage of the recently declassified documents made available in the post-Cold War era. The figure of Dwight D. Eisenhower has dominated this recent study and he has emerged as a much more effective leader than thought at the time. Eisenhower's leadership handling the Soviet Union in space now increasingly appears far-sighted and rational. To meet the challenge of Soviet aggression against American interests, Eisenhower supported the development of ICBM deterrent capabilities and reconnaissance satellites as a means of learning about potentially aggressive actions.[25]

Eisenhower established the right of international overflight with satellites, making possible the free use of reconnaissance spacecraft in future years. From the perspective of the Eisenhower administration, which was committed to development of an orbital reconnaissance capability as a national defense initiative, an international agreement to ban satellites from over flying national borders without the individual nation's permission was unacceptable. The tantalizing possibility exists that US space policy of the 1950s was predicated on allowing the Soviet Union to orbit a satellite first. Eisenhower was concerned that if the US was the first nation to orbit a satellite, the Soviet Union would have invoked territorial rights in space. Soviet Sputniks 1 and 2, however, over flew international boundaries without provoking a single diplomatic protest. On 8 October 1957 Deputy Secretary of Defense Donald Quarles told the President: "the Russians have... done us a good turn, unintentionally, in establishing the concept of freedom of international space." Eisenhower immediately grasped this as a means of pressing ahead with the launching of a reconnaissance satellite. This concept held for Explorer 1, which was launched successfully on 31 January 1958, and Vanguard 1, which failed in an attempted launch in December of 1957. By the end of 1958, the tenuous principle of "freedom of space" had been established in a de facto manner. In allowing the Soviet Union to lead in this

area, the Russian space program had established the US-backed precedent for free and unfettered access to space.[26]

Eisenhower largely ignored the American public in the immediate aftermath of the Sputnik launches in October and November 1957.[27] He was berated in the media and on the stump for this failure to deal with the domestic and international challenges and crises posited by Sputnik and there are still reasons to question his administration's ability to react to public unrest. Nevertheless, Eisenhower's leadership in the crisis of 1957-1958 yielded some of the most sweeping governmental reorganizations and new programs to be undertaken at the Federal level since the New Deal. Eisenhower reassured US citizens that efforts in space were on track and also met with science leaders and took these decisive actions:

> Established a Science Advisor, and the President's Science Advisory Committee, to coordinate basic research in the Federal government.
>
> Approved additional space research activities.
>
> Backed an International Geophysical Year (IGY) satellite program "to make sure we fire a satellite at an early date."
>
> Established the Advanced Research Projects Agency within the Department of Defense (DOD).
>
> Sponsored the National Aeronautics and Space Act of 1958, creating a single Federal organization, NASA, to manage civil space activities.
>
> Sponsored the National Defense Education Act of 1958 to stimulate the education, training, and research for science and technology.

These efforts have now been effectively analyzed in such works as Robert Divine's *The Sputnik Challenge.*

Civil/Military Relations in Space

There are several notable works that survey the interplay of civil/military relations in space as it deals with objectives and projects. The

classic study of the interaction between the civil and the military for the early period of the space age is McDougall's *...the Heavens and the Earth.* Another book by Paul B. Stares, *The Militarization of Space,* is also an important contribution to the subject. It establishes themes and analyses and has not yet been superseded although it is now more than a decade old.[28] The specific chapters on civil/military relations in the first two volumes of Logsdon's *Exploring the Unknown,* "Origins of US Space Policy: Eisenhower, Open Skies, and Freedom of Space" by R. Cargill Hill, and "Invitation to Struggle: The History of Civilian-Military Relations in Space" by Dwayne A. Day, are critical discussions of this subject as well. Alan Levine's *The Missile and Space Race* also makes interesting comparisons, as do some of the articles in the multi-volume *History of Rocketry and Astronautics,* containing the proceedings of the History Symposia of the International Academy of Astronautics, published periodically since 1986 and now numbering more than twelve volumes. The recently published history of the Air Force in space by David Spires also explores this theme.[29]

An intriguing but less well-developed aspect of this history deals with the way the two programs (civil and military) played off of each other and served as two sides of the same coin. Eric Chaisson makes the case that some of the technology of the Hubble Space Telescope was developed initially for the satellite reconnaissance programs of DOD, and that the problems with the space telescope could have been minimized had the DOD been more forthright in assisting NASA.[30] Equally intriguing because of how it fits into the civil/military component of space exploration is NASA's space station program. NASA began pressing for approval from the Reagan administration to build a space station in the 1980s; Reagan declared in 1984 "America has always been greatest when we dared to be great. We can reach for greatness again. We can follow our dreams to distant stars, living and working in space for peaceful, economic, and scientific gain. Tonight I am directing NASA to develop a permanently manned space station and to do it within a decade."[31]

The Reagan administration certainly viewed the space station as a part of its larger strategy to defeat the Soviet Union, the "evil empire" in Reagan's parlance, thereby raising the possibility of considerable civil/military dialogue concerning the endeavor. This involved a build-up of US military capabilities; a confrontational approach to foreign policy; assistance to US allies around the world, such as aid to rebels in Afghanistan; and the development of a multi-faceted set of new technological systems. Those ranged from the building of a 600-ship navy and "stealth" aircraft that could evade enemy radar to SDI involving the deployment of sophisticated space-based systems that could defeat Soviet missiles launched against the US. In this context, the Reagan administration's objectives for Space Station

Freedom, as it was called then, necessitated that it push American technological know-how so that spin-off systems might also be used in SDI and that it serve as a rallying point for the nation's allies. As a result, from the outset the space station had to be a high priority international program, for it was used to enhance the technical competence of US allies. Both a history of the space station decision and a monograph on the international partnership have been published that touch upon the civil/military nexus.[32]

National Sovereignty in Space Exploration

For years the issue of international competition and cooperation in space has dominated space exploration policy. Indeed, it is impossible to write the history of spaceflight without discussing these themes in detail.[33] The US space exploration program for its first decade and a half was dominated by international rivalry and world prestige, and international relations have remained a powerful shaper of the program since. NASA's human spaceflight projects, such as the Apollo program, the Space Shuttle, and the space station, have enjoyed as rationales for their conduct the furtherance of foreign relations.

At first there was the Moon race in which the two superpowers locked in Cold War struggle sought to outdo each other. No cost seemed too high, no opportunity to "best" the other seemed too slight. The astronauts planted the American flag on the surface of the Moon when the great moment came in 1969, not unlike the Spanish flag planted by Columbus in America. The irony of planting that flag, coupled with the statement that "we came in peace for all mankind," was not lost on the leaders of the Soviet Union who realized that they were not considered in this context a part of the "all mankind" mentioned.

With the successful implementation of the Apollo program, everyone realized that the US was the unquestioned world leader in science and technology and continued international competition seemed pointless. Certainly President Nixon, who took office in January 1969, made it clear that there would be during his leadership no more Apollo-like space efforts. Couple this with the great desire of those working for a continuation of an aggressive space exploration effort and the result could only be the search for a new policy model to justify the effort. While successfully continuing to tie space exploration to foreign relations objectives, now the linkage would be based more on cooperation with allies rather than competition with a Cold War rival. The exploration of space increasingly emphasized visible and exacting international programs. All of the major human spaceflight efforts, and, increasingly as time progressed, robotic projects, have been identified

since the 1970s with international partnerships and international space cooperation in mind.

International space cooperation has raised a number of issues about the nature of international relations in space exploration. A key one revolves around the issue of national sovereignty. Leaders of all nations make decisions on a daily basis that relate to others, either friends or rivals or in some cases both at the same time, and the nature of those decisions enhance or deflate national sovereignty. These decisions are at times played out in the space arena and involve levels of interchange that include bilateral and multilateral agreements, actions taking place in the United Nations, and international commerce. In such a cooperative venture as a major space exploration project, how do questions of national sovereignty affect the course of the effort?

For years such issues have affected the relations of the US and its European partners, as the various national organizations jockey and cajole each other and seek to gain advantage, competitive or otherwise, in space activities. John Krige has explained this issue in the context of the nations involved in the European Space Agency (ESA): "Any collaborative venture involves a partial loss of sovereignty for a nation. Inevitably, the question arises as to whether the benefits accruing from working with others outweigh the costs. Generally speaking, European governments have four main motives for collaborating scientifically and technologically: (1) the field of science is worth pursuing; (2) the technology developed is of importance for their industry; (3) material need (the savings in human and financial resources deriving from the pooling of efforts); and (4) political advantage."[34]

Such issues have prompted various nations to go their own way in space, notably in ESA's decisions in the 1970s not to accept the offer from NASA to cooperate in a post-Apollo space program (the effort that became the Space Shuttle)[35] and to indigenously develop an autonomous access to space (the effort that became the Ariane launch vehicle).[36]

Politics of Space Exploration

Without question the "Politics of Space Exploration" has engendered considerable research, much of it by political scientists engaged in policy analysis. After the overview of the Cold War political arena by McDougall, the classic analysis in this arena is Logsdon's exploration of Kennedy decision to launch Project Apollo.[37] These have been followed with similar policy studies concerning the decision to build the Space Shuttle and the International Space Station.[38] There has also been considerable discussion of

the role of the Presidency in shaping this policy-making process.[39] While there is less on the other political entities involved in the development of space policy, some efforts have been undertaken to explore the role of public pro-space groups (advocacy coalitions), of Congress, of scientific and technical elites (bureaucracy and public administration), and of business.[40] In fact, this very book on space policy, in the chapters that follow, focuses on these areas.

Although much excellent literature exists in both article and book form concerning the politics of space exploration, there are several avenues that require extended investigation and reevaluation in light of new perspectives that are coming to the fore. For instance, the post-modern linguistic view offers considerable opportunity for innovative examination. William D. Atwill's *Fire and Power,* as one example, uses the tools of deconstruction to comment on the development of space exploration as a "big science" program that masked the weaknesses of a "bankrupt" American society and prolonged faith in that society far beyond where, in his view, it was sustainable.[41] Likewise, Constance Penley's *NASA/TREK* and Jodi Dean's *Aliens in America,* offer truly provocative post-modern analyses of spaceflight and its meaning in the development of modern America.[42] The post-modern approach has yet to be fully explored but offers avenues for future studies of the politics of space exploration and its development over time.

So also does the incorporation of the methodologies and themes of the "new social history." The larger field of American history has been reenergized by the infusion of these new methodologies and questions. Those new questions, taken from the larger concerns present in this multi-cultural American society, have yielded interesting results. They all revolve largely around issues of power and influence and how they are played out in the themes of race, ethnicity, class, and gender. A sense of anticipation presently permeates historical study as it has incorporated these four building blocks to construct a largely new perspective on the master narrative of American history.

To help broaden the horizons of space exploration history, some of the questions prompted by the modern American multi-cultural civilization being asked elsewhere are also appropriate for the politics of space exploration. Such as questions of power: who holds it, and more importantly why they hold it and how they use it. To examine these issues in the context of space would take into account a social constructionist perspective that encompasses work being done on race, ethnicity, class, and gender.[43] An interest in these subjects would involve a commitment to the broad scholarly understanding of the nature and meaning of oppression and the inequalities of power as manifested through the space program in relation to these four areas.

Spaceflight and its Technological Legacy

There has been enormous exploration of the technology of space exploration projects. The largest single source for this has been the NASA History Series, which began publishing in 1963 and to date has issued more than 100 titles. Many of these are very specific project histories, and these have been the "bread and butter" of the NASA History Program including at least one volume each on Mercury, Gemini, Apollo, Skylab, Apollo-Soyuz Test Project, Ranger, Viking, and Vanguard, with others of a more general nature.[44] Those works were marked by well-defined and quite restricted parameters, documentary in tone, and research in primary source documents. Their documentary nature ensured that they were not attractive to academic historians, in-and-of-themselves, but always they provided source materials for other historians in the fashioning of interpretive structures.

These official histories of American space exploration programs have stood the test of time, but they were overwhelmingly exhaustive project histories with essentially the same strengths and weaknesses of similar works found in other Federal government historical works, such as the multi-volume "US Army in World War II" series produced by the Army on which they were modeled.[45] Not to criticize these path-marking efforts, for those works are valuable, but it is important to broaden subject matter and to free the interpretive parameters of space exploration and its technological legacy.

Some notable work in this regard, especially in relation to Project Apollo, includes books by Charles Murray and Catherine Bly, and by Andrew Chaiken.[46] There have also been discussions of this written by astronauts and other notables, including Jim Lovell's account of Apollo 13 and Tom Wolfe's story of test pilots and Project Mercury, both of which became major motion pictures.[47]

The concept of the social construction of technology has emerged as an important analytical tool in understanding and explaining the development of spaceflight. Pamela Mack's discussion of Landsat's development, for instance, analyzed the interrelationships of different governmental organizations (NASA, National Oceanic and Atmospheric Administration, Department of Commerce, Department of Interior, US Geological Survey) along with nongovernmental groups such as agribusiness concerns and international entities to show how the lack of communication hindered the development of what eventually became a path breaking applications technology.[48] In all instances, the social construction of technology emphasizes the web of political, economic, organizational, social, and technological issues faced in any large endeavor. Various interests often clash in the decision-making process, as difficult calculations have to be

made. A complex web or system of ties between various people, institutions, and interests are part of any space system, and each fundamentally affects the direction taken.[49]

Space Science and Understanding of the Universe

To some Americans, from the 1960s to the present, space has represented prestige and the American image on the world stage. That certainly drove the effort to reach the Moon before the Soviet Union. For others, it has signified the quest for national security. To still other Americans, space is, or should be, about gaining greater knowledge of the universe. It represents, for them, pure science and the exploration of the unknown. In the thinking and writing about space exploration, the first two views of American interest in space have eclipsed the latter. Indeed, the history of space science is one of the largely neglected aspects in the history of the space program.

There are only a handful of useful surveys of this subject, and those are of a popular nature.[50] Admittedly, there are several outstanding histories of individual science efforts, but space historians have been hesitant to explore several critical themes deserving of sustained attention. As space science activities move forward in the twenty-first century, many people are excited by prospects for the future. But, debates about accomplishments and priorities, as well as costs, remained unresolved. These concerns point out the difficulty of building the constituency for large science and technology programs in a democracy.

The political course of American and other spacefaring nations' projects provide important lessons about the nature of high-technology public policy. They are striking examples of what social scientists have called "heterogeneous engineering," a concept that recognizes that scientific and technological issues are simultaneously organizational, social, economic, and political. These interests could come together to make it possible to develop a project that would satisfy the majority of issues brought into the political process.

Human Imperative in Space Exploration

Why expend the enormous sums necessary for human spaceflight? That is one of the central questions of space exploration policy at present, and the question has not changed since the beginning of the space age. Along with historical studies of human spaceflight efforts, there must be efforts to

understand the evolution of this question. Some critics have appropriately suggested that without a long-term, integrated plan for human exploration and settlement of the Solar System that there is very little reason at present to fly humans in space. After all, the first task of any vehicle launched into space on which humans are aboard is to return those people safely to Earth. This means that the spacecraft's ability to accomplish scientific measurements will be impaired if ever those two goals come into conflict. Moreover, the cost of human spaceflight is so great that without some larger objective, such as the establishment of a human presence on the Moon or Mars, or even a space station with a permanent crew as is now the case with the International Space Station (ISS), the rationale is questioned.[51]

No group of individuals has captured the imagination of modern America in the same way as has NASA's astronauts. From the ticker-tape parades of the Mercury astronauts to the recent, and seemingly routine, missions of the Space Shuttle astronauts, this group of people has been imbued with a heroic aura. There has been, surprisingly, only a modest literature of a serious historical nature on the astronauts. For several years the starting point for any discussion of astronauts has been Joseph D. Atkinson, Jr., and Jay M. Shafritz, *The Real Stuff: A History of the NASA Astronaut Requirement Program.* The authors presented a brief overview of the selection of the first ten groups of NASA astronauts through 1984, then concentrated on covering the watershed selections of 1959, the first group, of 1965, the first scientists, and of 1978, the first Space Shuttle selections that included women and minorities.

The bravery of the astronauts touched emotions deeply seated in the American experience of the twentieth century beginning with those involved in Project Mercury. Each astronaut sat alone in the single-seat Mercury capsule, like the "lone eagle" Charles A. Lindbergh crossing the Atlantic Ocean only a little more than thirty years earlier. Facing personal danger, they fit the myth of the frontier.[52] As military test pilots, they recalled the sacrifices required to produce the Allied victory in World War II at a time when military service was still held in high regard.

As Howard McCurdy concluded: "The astronauts appeared at a time when NASA desperately needed to inspire public trust in its ability to carry out the nation's goals in space...astronauts seemed to embody the personal qualities in which Americans of that era wanted to believe: bravery, honesty, love of God and country, and family devotion."[53] Those early astronauts put a very human face on the grandest technological endeavor in history, and the myth of the virtuous astronaut was born with their public unveiling with Project Mercury in 1959. The Mercury seven astronauts were, in essence, each of us. None were either aristocratic in bearing or elitist in sentiment.

They came from everywhere in the nation, excelled in the public schools, trained at their local state university, served their country in war and peace, married and tried to make lives for themselves and their families, and ultimately rose to their places on the basis of merit. They represented the best we had to offer, and most important they expressed at every opportunity the virtues ensconced in the democratic principles of the US Republic.

Of great significance for future research is what could only be referred to as the cult of the astronaut.[54] In this the questions, issues, and perspectives about human spaceflight, too often are narrowly defined without incorporating the larger contexts that inform contemporary developments in other historical disciplines. Even so, the cult remains true, and while significant amounts of human spaceflight historical articles and books are being produced, few outside the immediate sphere of space boosterism take much notice of it. The plethora of astronaut memoirs, even those that are insightful and hard-edged, meld into the dominating framework of fawning, reverent works on the astronauts.[55] Serious, thorough exploration of the meaning of the astronaut in modern America still awaits its historian.

Finally, there can be no question that gender is a significant area requiring concentrated historical effort when it comes to the human element in spaceflight. There has been limited work on this subject dealing with the nature and work of women astronauts, and the perseverance of individual women. This area of study has not sparked the interesting explorations that could be undertaken by those working in the field. More illuminating than most of what has been done are the questions of gender and how and why the two sexes have interacted together in the space program. Joan N. Scott recently noted that historians have been slow to ask questions of gender in many areas, thinking that they bear little relationship to "war, diplomacy, and high politics." Scott challenged historians to move beyond the connotation of linking gender to women's history and to expand the investigation to broader human concerns.[56]

Making Life on Earth Better

Much has been made over the years of what NASA calls "spin-offs," commercial products that had at least some of their origins as a result of spaceflight-related research. Most years NASA puts out a book describing some of the most spectacular, and they range from laser angioplasty to body imaging for medical diagnostics to imaging and data analysis technology. Spin-offs have not only been Tang and Teflon, neither of which was actually developed for the civil space program.[57] NASA has spent a lot of time and trouble trying to track these benefits of the space program in an effort to justify its existence, and the NASA Historical Reference Collection has more

than five linear feet of documentation relative to the subject. With the caveat that technology transfer is an exceptionally complex subject that is almost impossible to track properly, these various studies show much about the prospect of technological spin-offs from the US effort to fly in space.

Whether good or bad, no amount of cost-benefit analysis, which the spin-off argument essentially makes, can sustain NASA's historic level of funding. More useful to this argument is a counterfactual question: how would life today be different if there were no space program? There can be no fully satisfactory answer to that question. But perhaps one can begin with the elimination of the microchip. Whether life would be significantly different is problematic to assess, but many of the high technology capabilities, such as biomedical diagnostics and related technologies, and telecommunications breakthroughs, might well have followed different courses and would have lagged beyond their present level of technology. There is evidence to suggest that the larger space program pushed technological development in certain paths that might have not been followed otherwise, both for good and ill.[58] It remains to be seen how historians might seek to look at the overall impact of space technology on American lifestyles.

A critical component of this subject is the application of space technology for practical use here on Earth. Remote sensing for climate data, crop monitoring, and global environmental change, and weather and telecommunications satellites have developed in an industry worth billions of dollars each year. How and why did this take place? What are its parameters, international partnerships, and internal politics? What evolutionary path did this follow? What public policy questions, what "new social history" questions, what social construction of technology questions, and what post-modern questions might one ask of this subject to understand it more fully?

One of the most significant areas affecting the reinterpretation of American history in the last generation has been the interaction and conflict of various classes in the nation. There should be no question that social, economic, educational, institutional, and other types of classes always have and continue to frame the context of the development of applications satellites and its use. Space exploration historians have mostly failed to identify and investigate this area. Howard Zinn's statement is appropriate for space exploration history: "There is an underside to every age about which history does not often speak, because history is written from records left by the privileged. We learn about politics from the political leaders, about economics from the entrepreneurs, about slavery from the plantation owners, about the thinking of an age from its intellectual elite."[59] One fruitful area is for space exploration historians to look at the theme of applications of space

technology and its relationship between the developed and developing world, and to issues such as sustainable development.

Space and Popular Culture

The relationship of space exploration to the larger popular culture has only been opened in a serious way in recent years. There have been several books of late that have become important in this arena. Post-modern analyses by William D. Atwill, Constance Penley, and Jodi Dean analyze the relationship between spaceflight and modern America.[60]

The most important work, however, is Howard E. McCurdy, *Space and the American Imagination.*[61] As a significant analysis of the relationship between popular culture and public policy, this work argues that the dominant trends in science fiction literature and film, as well as public perceptions, reinforce actual events in spaceflight and fundamentally affect public support for human spaceflight. McCurdy noted that during the 1950s and 1960s the relationship between reality and perceptions drew tightly together and created an expectation that allowed the accomplishment of the lunar landings. Since that era, the paths of public perceptions and actual events have diverged. A challenging interpretation that requires skepticism but also continued consideration, McCurdy has demarked an important area of consideration that will keep scholars working for years testing his hypotheses.

CONCLUSIONS

Even though the advocators and detractors of space exploration historiography are very much present, the real torchbearers of serious historical inquiry about the field are those in the center of the historiographical spectrum. If the history of spaceflight is to be understood, it will have to rely on those historians who do not seek to prove or disprove the legitimacy of space exploration. There is much positive to point toward in this aspect of historical scholarship about space exploration.

Of note are the works reviewed herein that attempt to coalesce a "New Aerospace History." Like the "New Western History" or the "New Social History" this approach represents a significant transformation that has been taking place in the field of Space History. Specifically, the "New Aerospace History" is committed to relating the subject to the larger issues of society, politics, and culture. This "New Aerospace History" emphasizes the whole technological system, including not just the technology, but also how technological systems are situated within the context of human culture and its

institutions. This is a theme that runs throughout this book on Space Politics and Policy as well.

The extraordinary and complex features of space technology have at times seduced historians to focus on the technology losing in the process a perspective on the human and social forces that are the essence of technological development. Because of this, most of the sophisticated work done in the history of spaceflight has come from those outside of the traditional aerospace history community. The "New Aerospace History" emphasizes research in space topics that are no longer limited to the vehicle-centered and internalist styles characterized by the traditional aerospace history literature.

2
RATIONALES OF THE SPACE PROGRAM

Roger Handberg*

INTRODUCTION

For the believer in outer space as the next human frontier, the "why space" question, the rationale for exploring space, is self-contradictory. The very existence of space as an unexplored and, until recently, an inaccessible physical location justifies the cause for exploring space. One view holds that humans, being curious and adventurous as a species, naturally reach out to explore, exploit, and utilize new and unknown frontiers. Another view is that exploration is not necessarily natural to the human experience. Space as an object of interest fascinates the public; however, the public when asked to choose between expanding the United States (US) national space exploration effort and doing other socially relevant tasks, most citizens consistently choose the latter category. Space has remained ancillary US public policy for most of its history.[1]

This reality means that continued pursuit of a viable US civil space program must incorporate a number of goals and rationales. What has occurred historically is that the US, usually through NASA, has expounded a rationale for the exploration of space within which are nested several diverse and complementary facets.[2] Those various facets rise and fall in importance and intensity with which they are pursued across the decades as US space policy responds to dramatic changes in the international and domestic political climates. This chapter sketches out that evolutionary path, focusing upon the past and present as a prelude to the future. Individuals often disagree as to the relative weight that should be assigned each facet at a particular time. The public disagreements usually reflect differences not in desired goals but in the intensity with which each are being pursued. For example, disputes have arisen over the relative importance assigned human spaceflight in comparison to space science undertaken by robotic probes.

One must also acknowledge that there also exist those whose viewpoints reflect continual rejection of any significant governmental civil space program. Given the increasing ubiquity of space applications directly applicable to daily life, such a perspective might be more supportable today as

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the commercial space sector expands to meet the burgeoning demand for their services.[3] Earlier, such a perspective made less sense, as no independent commercial space sector existed. Those in this sector reject human spaceflight as just another costly foreign policy driven venue that is wasteful of resources.[4] Others saw space programs as nothing more than an issue of prestige, a monument to the modern state and human pride. Albeit these views are counter justifications for a civil space program, they have influenced the process by which the rationales for such a program have been constructed and have played a role in the evolution of US space policy.[5]

FRAMING THE ANALYSIS

In considering rationales, one must begin with the clear understanding that the entire US civil space enterprise originated in the public sector. Whenever one desires to expend public funds for a public purpose, the reasons advanced must be persuasive across a broad spectrum of political factions and advocacy coalitions, including both potential supporters and opponents. The simple fact is that space expenditures are minimal compared to defense or social expenditures. This difference can be seen annually in the arguments advanced in Congress concerning NASA expenditures. A believer in space's enormous scientific and economic potential may feel that space by its very existence justifies such tremendous expenditures. Concomitantly, public officials operate in a larger political context within which other equally worthy causes and their group representatives, such as advocacy coalitions, stridently demand their full attention. This political competition is exacerbated by the fact that governmental resources for a particular public policy are usually limited and must be spread across multiple actors and policies.

The existence of such competition means that the public rationales advanced must clearly be persuasive at several levels of argument. Rationales must meet the perceived needs of relatively large and diverse economic and political constituencies. Advocates have to create needs or meet expectations about the future. This is especially critical for a new field as space exploration initially was. Immediate policy successes do occur but long-term financial commitments ultimately determine the degree of success achieved. Consequently, no single rationale or justification can meet the political needs; rather, different facets are emphasized at various points in time.

Given both the large public sums required and the initial vagueness of any promised results, a particularly strong political incentive was required to push space efforts forward. The vagueness of results implies that until space was actually physically occupied on a continuing basis, it remained somewhat

unclear what exactly could be accomplished. From 1945 onward, Earth-orbiting satellites were considered realistic; their successful employment required real time experience rather than hypothetical conjecture.[6] Space's physical environment raises unanticipated hazards, continually demonstrating the inadequacies of earlier solutions. For example, satellites encounter solar flares and orbital debris outside the parameters of what is expected. Space activity remains a continual learning experience.

Space advocates pushed forward a variety of purposes for exploring and utilizing space, part commercial, part scientific, and part military, although all these activities were wrapped up in the overriding vision of humans exploring space. Even though human spaceflight was central to the vision, it clearly remains the most politically challenging and expensive task to achieve successfully. Further, once humans along with their machines arrived in space, the future remained less than clear regarding the actual benefit to society. There was the honor and thrill of being "first" to land a man on the Moon, but why one should go back was the real question. Being first was an expensive political prize of the Cold War if that was all that occurred.

One needs an incentive, a compelling focusing event, strong enough to break through the existing political status quo and to place the issue of space on the policy agenda for political decision-making and policy formulation. The lack of a focusing event delayed the US from orbiting a satellite first. This was so despite the fact that programmatic options and the technology for space activity existed in the early 1950s. Clearly, other political priorities intervened which prohibited taking effective action prior to the Soviet Union's launch of the world's first orbiting satellite in 1957.

The focusing event came with the October 1957 Soviet launch of Sputnik 1 followed by an even greater mass Sputnik 2. Sputnik was part of the Soviet participation in the International Geophysical Year (IGY). The US had also agreed to participate in IGY through its quasi-civilian Vanguard "satellite" program. IGY was a scientific program organized on the support of national governments throughout the world. Its scientific goal was to survey the geophysical environment of Earth from outer space. From the beginnings of the space age an important rationale for US space activity became scientific exploration. This began with exploration of Earth's near space environment and expanded beyond Earth orbit to encompass other celestial bodies and astronomical observations of the cosmos.

The US Earth-orbiting satellite program carried a dual burden: scientific exploration of outer space and critical national security implications. From its inception the US space program has been immersed in international politics and served several purposes simultaneously, including the legal

precedent involved in establishing the right of free passage for satellites in Earth orbit. Airplanes violating national air space are subject to interception and possible destruction. Satellites in the 1950s represented a particular unknown as to the legal issue of the extension of sovereignty over air space to outer space since at that time no country possessed the technical capability to intercept an orbiting satellite. The possibility of diplomatic protest denying the political acceptance of unimpeded overflight by satellite existed. This implied that later when an antisatellite capability was achieved, interception would follow as a matter of course. The Sputnik successes were followed in January 1958 by the US Explorer I satellite; both occurred without public or governmental protest and answered the legal question of overflight. Peaceful free passage in space for all nations became the legal norm and custom, and by 1967 was codified as one of the legal foundations of the Outer Space Treaty.

Free passage implies that all satellites pass above the Earth's surface without hindrance. As such, international regulation of satellites was necessary. An elaborate set of policies and rules gradually came into force under the auspices of the International Telecommunications Union (ITU) to prevent interference by different satellites regarding transmissions from other satellites and their passage through space. Later, more elaborate rules were established via the International Telecommunications Satellite Organization (Intelsat) allocating scarce economic assets such as satellite location along the orbital arc (orbital slots) and geosynchronous orbits. Operating within these international understandings became the legal norm.

In terms ofjustifying a US space program, the two Sputniks provided a sufficiently strong political crisis to create intensified support for that effort. The Soviet government pushed hard on the theme that Sputnik established without equivocation their ability to threaten American security.[7] As a consequence, American space policy was buffeted by the squalls of domestic public opinion, demanding something be done. This episode created the strong pressures for making space policy an adjunct of national security policy rather than emphasizing the pursuit of peaceful activities, such as scientific exploration and commercial development. The concern for national security drove the field for years, and still remains an important issue. What occurs in American space policy today, relative to the rationales supporting the overall program, grew out of that formative experience- one shaping both expectations and institutions. In fact, NASA itself arose out of that Cold War crucible.

The rationales articulated have appeared in a variety of forms: policy statements and speeches by public officials including the President; policies by NASA and other government players; laws passed by Congress; policy statements by national commissions; and visions of the future by space

advocacy coalitions. The space program is surrounded by political groups interested in influencing its future directions. Industry and the various scientific societies and research organizations have a material and an intellectual interest in what occurs. Advocacy coalitions come to the table with diffuse and at times competing motivations. Government participants have historically been influential because they provide the resources, leading the field in particular directions.

NASA's outreach activities are responsible for getting the Agency's message out to the public.[8] The goal is to articulate the message in an interesting and relevant form to the public who ultimately fund the Agency's work through tax dollars. These activities can involve both curricular support of K-12 programs and broader community outreach forums through local groups and schools. Regardless, there are countervailing players, especially the commercial sector, whose views differ from those espoused by NASA. The rationales supporting the US space program have arisen from the interplay between these diverse and often competing interests. At times, NASA feels that its particular message gets lost in the cacophony of politics.

Table 2.1 provides examples of major public statements regarding space activities. Some are critical, as is the Rogers Commission report regarding the Challenger accident directed at putting the American Space Shuttle program back on track. The first two examples, *Collier's* and the Disney television feature on "Man in Space," represent unofficial expressions impacting public policy debate. Indeed, both *Collier's* and the Disney feature created an atmosphere conducive to supporting a larger vision of human space activity.

President Kennedy's speech before Congress in May of 1961, where he advocated landing a man on the Moon by the end of the decade of the 1960s, serves as an expression of presidential leadership that drove US space policy for a decade. As can be seen from the listing in Table 2.1, the more usual statements are presidential policy directives and reports by advisory groups of differing pedigrees. Most Presidents since Eisenhower sign formal statements of their administration's space policy. Advisory committees are a time-honored method of presidential advice seeking. In some instances the committee recommendations are superseded by a change in administration (e.g., Ad hoc Panel on Man-In-Space) or by events (e.g., Pioneering the Space Frontier). Others just have their recommendations rejected by the administration because the report does not meet its needs (e.g., Space Task Force).

Table 2.1. Public Policy Statements Regarding Space Activities.

Author	Title	Date
Editors, *Collier's*	"What Are We Waiting For?"	October 1952
Walt Disney	"Man In Space"	March 1955
National Security Council (5814)	"US Policy On Outer Space"	August 1958
President's Science Advisory Committee	"Report of the Ad-hoc Panel on Man-in-Space"	December 1960
President Kennedy	"Urgent National Needs" (Speech to Congress)	May 1961
NASA	Summary Report: "Future Programs Task Group"	January 1965
Space Task Force	"The Post-Apollo Space Program: Directions for the Future"	September 1969
President Carter	Presidential Directive: "Civil And Further National Space Policy"	October 1978
President Reagan	"National Security Decision Directive: National Space Policy"	July 1982
NASA	"NASA Commercial Space Policy"	October 1984
Presidential Rogers Commission	"Report of the Presidential Commission on the Space Shuttle Challenger Accident"	June 1986
National Commission	"Pioneering the Space Frontier"	May 1986
NASA Task Force (Ride Report)	"Leadership and America's Future in Space"	August 1987
President Reagan	Presidential Directive: "National Space Policy"	February 1988
President Bush	"Space Exploration Initiative"	July 1989
President Bush	"Commercial Space Launch Policy"	September 1990
Augustine Committee	"Report of the Advisory Committee on the Future of the US Space Program"	December 1990
President Clinton	"National Space Transportation Policy"	September 1994
President Clinton	"National Space Policy"	September 1996

Any suggestions supporting space activity and setting future directions run a gauntlet of political and fiscal practicality problems that are an inherent part of public policy. Over time, political justifications decline in relevance or events remove them from the public policy agenda altogether.

Thus, each presidential administration, even if disinterested (e.g., the Carter Administration), must develop a rationale for space that fits its policy agenda and political needs. This requires a continuing process of policy adjustment and change. Space advocates inside and outside the government are often frustrated by ongoing policy change that has made and continues to make the formulation and implementation of space programs problematic.

STABILITY AND CHANGE

Current space activities are outgrowths of rationales, programs, and trends set in motion years beforehand. Presidential administrations build on the handiwork of the past for several reasons: the issues have been thoroughly researched, thought about, and hashed out by bright people; the obvious has been discovered, considered, used, or discarded (the latter usually for good reason); space activity is a large-scale endeavor; and previous decisions structure future choices because budgets are limited. Revamping programs is unlikely to be a productive choice as one moves the US political system incrementally in new directions.

Rationales for US space policy have fallen into distinct clusters as depicted in Table 2.2. The argument is that early events laid the basis from whence flowed both the specific programs and activities operating today along with their supporting rationales. This is a capsule view of the space age strictly from an American perspective.

Table 2.2. Rationales and Space Policy.

Time Line: **Activity:**	**Beginnings**	**Present**	**Future**
Military	Military Space	Force Support Force Enhancement	Space Control Force Application
Scientific	Space Science	Earth Science Astronomy	Planets Asteroids Environment
Civil	Human Spaceflight	Space Shuttle Space Station	Human Habitation Human Exploration
Commercial	Technology Development	Commercial Applications	Economic Competitiveness

In Table 2.2, the timeline moves forward from the beginnings to the present and into the future helping to place different events into their proper historical sequence. The dawn of the space age begins in 1957 as Sputnik entered orbit, represented by "Beginnings," a period running roughly across the first years of the space age, the Apollo-era. The "Present" encompasses the post-Apollo period, while the "Future" is located in the twenty-first century. Unlike Sputnik'*s* launch, subsequent time periods, the present and future, are not clearly delineated by a singular focusing event, instead they reflect trends that emerge into prominence or fade away on policy agendas. The point here is to provide a broad perspective for the historical movement of events and the supporting rationales justifying the specific activities.

American space activity whether military, scientific, civil, or commercial emerged originally from within the driving issue of national security. This issue has been designated the "prime mover," meaning that public concern regarding this question was sufficiently strong to generate intense political demands for an expansive American space effort. Despite great reluctance on the part of President Eisenhower, he was politically pressured to expand American civil space efforts to include human spaceflight.[9] National security, operating as the justification for space activity, reflected the historical context of the Cold War, an international political-military-economic competition occurring between blocs led by the US and the Soviet Union respectively. In 1957, those alliances were locked in an intense duel for world leadership; space activities were incorporated into that competition because of their military relevance.

The rocket that placed a satellite in orbit also possessed the capacity to deliver a nuclear warhead. Accordingly, falling behind in peaceful space activities was perceived as evidence of lagging behind in the competition for strategic nuclear missile superiority. The fallacy of that view became only clear in retrospect.[10] Sputnik and the political fallout from that event created incredible political pressures to be "first" and technologically ahead of the Soviets. Only after those events, with the ending of the Cold War and collapse of the Soviet Union, did the original national security rationale for a national civil space program become secondary, allowing for fuller articulations of other rationales. National security has never faded out of the picture, but the emphasis has become less military and more concerned with economic competitiveness.

Since Sputnik, four major themes arose to justify a large-scale American space policy. Those themes have played out in the past and will continue in different forms into the future. Specific programs have fluctuated over time but were worked out within the boundaries of these general interests. In Table 2.2, the intention is to provide some examples of programs whose justification flows from the larger theme in which they are embedded.

Although this chapter focuses primarily on scientific, civil, and commercial space activities, military space underlines all of the other activities since civilian space and commercial space often flowed out of military endeavors.

In addition to the four major rationales underlying US space efforts, explicit mention must be made of the sub-theme of international space cooperation. Internationalization of space activities was enunciated as a goal from the beginnings of the space age (e.g., IGY). The National Aeronautics and Space Act of 1958 establishing NASA contained the statement: "...cooperation by the US with other nations and groups of nations in work done pursuant to this Act."[11] Interactions with potential international partners, such as the Soviet Union, were limited by Cold War politics. Adversaries were perceived as unlikely partners, notwithstanding rhetorical gestures that were made soliciting their cooperation. President Kennedy, even after proclaiming the Apollo Program as a national priority, sought later before the United Nations (UN) to jointly fly to the Moon with the Soviets.[12] Concurrently, given the strategic military balances of the Cold War, cooperative offers were made toward US allies. Those efforts began in the 1960s, but were always restricted by national security and technology transfer concerns.[13] Nevertheless, from the beginnings of the space age international cooperation was an integral part of space activities, especially regarding space science programs.[14] The current multilateral cooperation on the International Space Station (ISS) became an extension and amplification of space cooperation.

Military Space Activity

Military space activity has proceeded through several stages in development. From the beginning, securing the US from nuclear holocaust was the primary goal. Initially, the issues involved establishing a sufficient reliable military space presence to enhance the effectiveness of American strategic nuclear forces.[15] That effort led to other efforts aimed at developing elaborate missile detection and warning systems along with a reconnaissance capacity sufficiently accurate to override Soviet secrecy. Finding targets behind the Communist "Iron Curtain" was an absolute priority if American nuclear deterrence was to work. The space station depicted in the Disney feature listed in Table 2.1 was a reconnaissance system by which the Soviet Union and the rest of the globe could be observed.

From the Eisenhower Administration onward, military space activities have largely been conducted in secrecy or at least within a low profile, minimizing public visibility and awareness of the extent of those

activities.[16] One important thrust has been the extension of military command and control functions to the theater level. The earlier space-borne assets were reconfigured to provide force support and force enhancement at all levels of the military activity spectrum. More recently, the US military has begun examining and testing space-based technologies aimed at protecting US space assets, whether they are military or nonmilitary, while creating the capacity to deny an enemy access to orbit.[17] This involves space control and force application.

Scientific Space Activity

Achieving access to space attracted serious attention from the beginning because of its potential for expanding human knowledge about the Earth and the cosmos. Satellites in Earth orbit provide insight into the physical processes affecting the Earth. Several themes have been built into this rationale extended to support space science activity. At one level, there exists the idea of the pursuit of abstract knowledge– knowing more about the Earth and cosmos in order to expand the human mind.[18] This can be seen in the first reason advanced in the NASA statute: "...the expansion of human knowledge of phenomena in the atmosphere and space."[19]

Space science has continually drawn verbal and fiscal congressional and presidential support but it has proven less important than the pursuit of knowledge capable of some social or economic payoff. Consequently, since the earliest days the rationales have equally emphasized the likely rewards for pursuing such knowledge: "...establishment of long-range studies of the potential benefits to be gained from...the utilization of aeronautical and space activities for peaceful and scientific purposes."[20] Originally, the benefits to be obtained were somewhat unclear because no one really knew whether long term operations in space were possible.

More recent expressions regarding this theme have become explicit as the emphasis shifted to Earth science, especially in regard to the environment. NASA's Earth Science Enterprise, justified by the need to establish the social relevance of space activities, assesses global change phenomena. If governments are to make informed decisions concerning critical environmental issues, a better knowledge base must be demanded to support those decisions. The acquisition of knowledge can engender policy learning that could counter the strong ideological strands running through environmental policy debates over such issues as global warming. This, in turn, can lead to policy action aimed at mitigating further global environmental change.

The pursuit of knowledge in different forms has been central to the rationales advanced for US space policy. For example, space science budgets have been tapped several times to support other programs. Albeit science activities were not particularly prominent in the Apollo program, they grew in importance once the first landing on the Moon occurred.[21] Moreover, space opened up an enormous number of avenues for further scientific research. Given cost constraints on space science programs, only a comparatively few missions and scientific questions can be pursued in any depth at a single time. Currently, robotic Mars exploration and questions of the "origins of life" are dominating the policy agenda in the space science arena.

Civil Space Activity

The centerpiece of American space activities has been the sending of humans into orbit. In early 1958, before Congress established NASA, a committee reported to the future Agency regarding the composition of the national civil space program.[22] In that report, manned spaceflight was listed as a priority, a position ratified by the Agency in its first "Long Range Plan."[23] Human spaceflight has remained a major thread in civil space activities. The dream was first reaching orbit and then establishing a permanent human residence in space. The Moon came early due to a political aberration (e.g., Cold War competition), not duplicated since then.[24]

ISS is currently the linchpin around which US crewed space efforts revolve.[25] Cost was clearly the stumbling block in the post-Apollo era and remains a concern. Placing humans in orbit on a continuing basis changes the dynamics of space policy creating opportunities otherwise not available, such as industrial level microgravity manufacturing. Other space-based research activities become doable because long-term exposure to the space environment, whether internal or external to the spacecraft facility, is possible. Another argument made is that the presence of humans in space opens unanticipated opportunities because human ingenuity and observational talents will create new vistas. "Man has the capability of correlating unlike events and unexpected observations, a capacity for overall evaluation of situations, and the background knowledge and experience to apply judgment that cannot be provided by instruments..."[26] Human flexibility was best observed in the Space Shuttle missions to service the Hubble Space Telescope where unanticipated repairs were identified and solved on the spot by the astronauts.

The dream of humans living in space has been the core theme of much of the space literature.[27] Critics, among them space scientists, argue

that humans clutter up the situation, making it too expensive to complete tasks that a robot could more cheaply accomplish. Politically speaking, humans in space has been an essential part of the justification for space policy in that those individuals personalize what otherwise is a distant and alien environment. From the Mercury astronauts onward, space voyagers have been a glamorous group.[28] Loss of human spaceflight, it is argued, crushes the dream and is a defeat for the human spirit. NASA's "Return to Flight" after the Challenger accident was in part based upon that premise; humans must move past the tragedy to reassert their destiny.[29] The US has incorporated such activities into the essence of its space program, sustaining its crewed flight operations despite the tremendous costs involved, operational difficulties, tragedies such as the Apollo 204 fire and the Challenger explosion, and budgetary and international political complications as has been the case with ISS.[30]

Commercial Space Activity

Space activities are technologically challenging exercises. The successful overcoming of those challenges was in-and-of-itself deemed an important justification for the commercialization of space. Nations capable of sustaining space commercialization were major world economic competitors and are viewed in international politics as modern developed states. Space technologies demanded skilled and well-trained work forces whose talents could be disseminated into the larger technological and economic base of the nation. Apollo was developed into an economic engine for the Southern States of the US and represented a "Space Age America." This "Space Age America" idea served as powerful rationale for Apollo in that those who held this view, among them President Johnson, believed that the technology mobilized and harnessed by the government for sending men to the Moon could be applied to solve the social ills of the country. In the post-Apollo era, NASA established a series of Commercial Space Centers between industry and universities to foster space commercialization. The economic rationale has become stronger and even more explicit as space applications, such as telecommunications and remote sensing satellites, are important for sustaining US global economic competitiveness.

The Reagan Administration was the first to expound the economic impact of space applications by enlarging the private sector's role while reducing the government's role. This altered the dynamics under which commercial space activities occurred. One example of this is the "National Space Policy" promulgated in 1982. "The US encourages domestic commercial exploration of space capabilities, technology, and systems for

national economic benefit."[31] As the US government copes with the end of the Cold War and the global war on terrorism, the issue of national security restrictions on the process of space commercialization has come to fore for the space commercial sector.[32] Space technologies are becoming the means by which other high-tech applications can be facilitated. Government space activity, through the Department of Commerce and NASA, has helped the development of space commercialization. President Clinton's 1996 Space Policy and the Commercial Space Act of 1998 are important examples of public policy that facilitate thistrend.

The Commercial Space Act is a landmark public policy mandating commercial activities in space that have been previously dominated and controlled by the government. These areas include Global Positioning System (GPS), acquisition of space science and Earth science data, and space transportation services. The Act calls for the government to make use of commercial space technology rather than to develop these technologies or capabilities on its own, and for the government to make use of its own space assets to promote space commercialization. NASA has in place an ISS commercial development plan, and the US military recently saved the Iridium satellite constellation from a planned de-orbit by making use of the global satellite network for its own communication needs.

CONCLUSIONS: RATIONALES AND EVOLUTION OF SPACE POLICY

The research literature that examines the rationales underpinning the US space program is fairly sparse and highly selective. This state of the literature is a function of the space policy field's development. Many of the writers engaged in space policy analysis have been policy participants and advocates, meaning their analyses are focused upon explicating and justifying their viewpoints regarding the issues of the day.[33] The most prominent writers have been direct participants in the space program including Wernher von Braun[34] and Carl Sagan.[35] Advocacy literature is typical because the policy choices are controversial. For instance, the current debate over the feasibility of reusable launch vehicles (RLVs) generates controversy between economics and technical feasibility. This occurs in advance of any demonstration of the RLV concept in actual flight, resulting in literature that focuses upon technological specifics rather than the broader political contours embodied in rationales.

Academic observers, who write in the area of space policy, put forward analyses that are either technical-analytic focused or policy-studies oriented. In the former case, the focus is on effectively accomplishing the

specific mission or overcoming a particular technical problem where political issues are external to the frame of reference. There is a disjunction between practitioners and policy-makers due to this myopia. Public policies by definition involve politics, and analyses that fail to incorporate such insights remain incomplete. In the latter case, researchers tend to concentrate on how a particular program meets its programmatic goals.[36] These program goals flow from the broader rationales discussed herein yet the very rationales underlying the goals are either unexamined or are assumed to be fixed and agreed-upon. Such a disconnection is typical of academic disciplines where certain fundamentals are assumed to be true; therefore, the research focuses on the factual issues generated by those rationales.

Another factor impacting the development of the space policy field is the original public policy setting in which the field developed. During the Eisenhower Administration, there was a potent counter-critique regarding what the US space program should entail in terms of rationales and programs. Kennedy's endorsement of the Apollo Program and the acceptance of a comprehensive US space program stymied that debate. Alternative views were perceived as statements by political outsiders, from both the left and the right, and the self-interested. Those who felt the monies should be used for other activities, such as social welfare, were unsuccessful. Others were dismissed as self-interested because they, usually space scientists, advocated not fundamental change but a recasting of priorities to favor scientific interests rather than human spaceflight.

The literature that tends to deal somewhat with rationales is found in histories being written concerning the space age and the US space program.[37] McDougall's *...the Heavens and the Earth: A Political History of the Space Age* recast how the space policy field's development is perceived.[38] This publication was explicitly political in its focus and comprehensive in its historical breadth. A critical evaluation of the policy choices made by President Kennedy were placed by McDougall in a broader historical context in which their impacts could be assessed relative to the US space program's long range goals and development.

Additional literature that bears on rationales is the NASA-funded series detailing the documentary history of US space exploration and development of space. Under the editorship of John M. Logsdon, a series of historical volumes and survey essays present analyses of different facets and phases of the US space program.[39] The importance of these volumes is the identification of the general themes supporting the extension and continuation of the American space program. Each survey essay in these volumes is followed by excerpts from official documents created at the time. The essays reflect the assessment of the authors, but those interested are provided access to the source materials that can lead to further examination. Much of the

source material regarding the creation and agenda-setting for the American space program can be found within these volumes.

Space policy literature that uses Presidents and their administrations as the unit of analysis is also useful to assess the issue of rationales. This type of analysis is based on the fact that each President approaches the space program from a different perspective as indicated in Table 2.1; Presidents and their advisors respond to ongoing political events, opportunities perceived to exist, and their evaluation of the intrinsic worth of the program. Presidents Nixon and Carter expressed great skepticism as to the value of human spaceflight, while Presidents Reagan and Bush (89) articulated grander visions, including the space station in 1984 and the aborted Space Exploration Initiative (SEI) of 1989 that called for the establishment of a lunar base and human missions to Mars.

One study by Eugene M. Emme provides an earlier perspective upon the evolution of space policy through the different presidential administrations.[40] This study, however, occurred prior to the Space Shuttle and its subsequent problems. Logsdon's survey essay in the NASA history of the US space program provides a perspective on Presidents and space policy that includes the Bush Administration (89).[41] This perspective covers several crises including the Space Shuttle Challenger accident after which NASA and the space program had to reestablish credibility. An additional publication has explored the development of space policy from the perspective of whether Presidents in fact do lead the space program as it deals with the establishment of programmatic goals and priorities.[42] This volume offers a different perspective in that analyses are written by scholars whose research specialty is on a particular President and administration. The volume provides insight into the justifications for particular space policy choices made by the different Presidents.

In all these aforementioned analyses, the rationales are only indirectly examined. As this chapter suggests, the central themes underlying the rationales of the US space program were largely established in the late 1950s. Since that time, different variations of the same basic underlying rationales in response to changing political environments have been utilized for support of space policy decisions; but the underlying rationales, such as support of a human presence in space, has not changed despite changing historical conditions and differences in presidential ideology and policy.

One book that comes closest to directly examining the rationales underlying the American space program is Howard McCurdy's volume exploring the impact of space as a concept rooted within the American imagination.[43] This work traces the development of the concept of space and shows how that development is linked to pulp fiction. McCurdy's analysis

illustrates the fascination technology holds on the American psychic and how space plays into that perception. Embedded in this work are the four themes articulated in Table 2.2.

The US established a hierarchy of rationales justifying its space activities. This intellectual structure has endured in an interesting way; much like a diamond, different facets of the gem glitter with greater luster at various points in history– rising and falling on policy agendas– but they remain a coherent set of ideas and concepts supporting an expanded view of the human presence in space whether actual humans or their machines.

3
ADVOCACY COALITIONS AND SPACE POLICY

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INTRODUCTION

Even though organized advocacy groups, in particular those aligned with various space-related industries, often have the capacity to shape and drive public policy, that influence is not one-dimensional. Groups, even powerful ones, are not always in control of their own destinies, nor can they assume that their interests will be reflected in public policy decisions. If this were so, public policy would look a bit different than it often does. For one thing, if advocacy groups had the clout so often presumed of them, the space program throughout the 1990s probably would have been larger and more central to United States (US) policy-makers' concerns. It is useful to note the significant growth over the past few years in the budgets of almost all federal research and development (R&D) agencies except for NASA.

The array of interests surrounding the space program should play dominant roles in shaping national decisions on space. This web of interests includes the nation's major military and space contractors, their affiliated labor unions, the suppliers connected to these industries, an entire scientific and technical community, and a wide array of groups focused on broad foreign and national security issues. Taken together, these groups certainly represent potent economic, societal, and political interests. So why is it that these groups have relatively little clout in the formulations of space policy?

Maybe that's not the correct question. Possibly the correct focus should be on the kinds of space policy issues that are open to group influence and those that are not. A rough analogy to defense policy is appropriate here. Defense industries may have a lot of influence in Congress and the Department of Defense (DOD) on decisions involving choices among competing weapons systems. But do these groups really shape "defense policy" any more than they shape "space policy?"

To understand this question, this chapter examines the notion of space policy "advocacy coalitions" and the role they play in defining the issues

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central to the US space program. In doing so, the roles played by industry groups in agenda-setting and formulation are examined, asking in particular whether advocacy groups played primary or secondary roles in space policy formation.

ADVOCACY COALITIONS AND POLICY AGENDAS

Political scientists who study public policy invariably turn their gaze to interest groups. The simple reason is that all of the dominant concepts about policy-making deal with group theories, concerned with the interplay among interest groups and their connections to government. Groups matter, though how much is in dispute. There are winners and losers, actors and interests enjoying variable success in their ability to influence policy decisions. The real question is why some advocacy groups succeed while others fail to influence the policy formation process.

The conceptual debate over interest group power is a well-plowed field. Elitist critiques of the US democracy focus on the inequitable distribution of economic and political power. Pluralists reject such depictions of power as reputational and static, and argue that power cannot be understood nor measured until the focus is on a specific policy conflict. Where elitist theorists see strata of economic and social power, pluralists see political competition between multiple and partially overlapping elites, none of which possesses comprehensive and enduring political power. "A central and guiding thread to American constitutional development," argued Robert Dahl, "has been the evolution of a political system in which all active and legitimate groups in the population can make themselves heard at some crucial stage in the process of discussion."[1] Pluralists agree that the "strongest" might still prevail in a given conflict, but note that the victors in one instance may not even be involved when it comes to another policy issue. Different issues attract different interests, and on some matters the wealthy and powerful may lose out to better-organized coalitions of the less affluent.

The pluralist assumption that the "interested and the active" will mobilize and actively defend collective interests are challenged by studies that find political awareness and participation to vary directly with socioeconomic status and education.[2] Pluralists admit that society is unequal; but they deny that political outcomes invariably benefit the most affluent and educated. The critics argue that pluralists gloss over the misdistribution of power in society for the sake of some political egalitarianism. Pluralists may contend that every group involved in the fight has a plausible chance of success, but their critics counter that the game itself is stacked against the lowermost strata. Not every interest is or will be represented in the formation of policy.

These contrasting viewpoints about power were supplemented by a series of classic studies of policy-making in agricultural, water, and public works programs that came to constitute the core of the "subgovernment" approach to power.[3] These issue-specific studies, taken together, produced an image of sectarian politics, where policy dominance "is said to be vested in an informal, but enduring series of reciprocal relationships linking executive bureaus, congressional committees, and interest group clienteles with a stake in particular programs."[4] Subgovernment theorists agreed with pluralists that issues defined political action, but also noted that the arena for action is not open to all. In this image, policy-making is not so much a pluralist brawl as it is a private club.

Subgovernments are grounded in the clientelism typical of any narrowly configured participatory community. Effective access to decision-making is open only to those with the most direct economic or political stakes in the policy. The issues settled within such configurations of policy actors tend to show low public visibility, and decisions emerge through mutual accommodation, where all involved tend to gain. Such arrangements simplify governance because they narrow the range of actors and choices attendant to any issue, and they make policy-making less global and more sectarian. Subgovernment policy-making also is inherently incremental, since great changes only attract unwanted attention.

The subgovernment school dominated the study of public policy-making through the 1970s. Beginning in the late 1970s, however, subgovernment approaches became increasingly ill suited to explain public policy-making in the more amorphous and inchoate configurations of participation and influence that characterized US politics. Subgovernments inadequately conveyed the complexity of policy-making. In most initiatives taken over the past two decades (1980s and 1990s), it is all but impossible to identify clearly who the dominant actors are. "Looking for the few who are powerful, we tend to overlook the many whose webs of influence provoke and guide the exercise of power."[5]

These "webs" of policy influence or what is termed "issue networks" include elected officials, bureaucrats, the media, and policy experts of every stripe. If the concept of the subgovernment implies a relatively stable and exclusive set of relationships among public and private sector actors, the issue networks by contrast comprises a larger number of participants with quite variable degrees of mutual commitment or of dependence on others in the political environment. Subgovernments conjured up images of exclusive and autonomous decisional units, while the issue network is far more transitory. At the same time, it does not suggest pluralism-as-usual or, for that matter, the

lack of discernible connections among those who know each other through an issue.

Charles O. Jones, studying American energy policy in the 1970s, suggests an image of “sloppy large hexagons” to clarify the issue network concept. On the assumption that national energy policy, such as it was prior to the Organization of Petroleum Exporting Countries (OPEC) oil embargos of the 1970s, was dominated by subgovernments, these arrangements are scrambled completely during the “energy crisis”:

> Demands by environmentalists and public interest groups to participate in decision-making, involvement by leadership at the highest level in response to crisis, and the international aspects of recent energy problems have all dramatically expanded the energy policy population. Note that the expansion is up, out, and over– up in public and private institutional hierarchies, (e.g., the involvement of Presidents and countries, rather than just low-level bureaucrats, and of congressional party leaders rather than just subcommittees); out to groups that declared an interest in energy policies (e.g., environmentalists, public interest, and consumer groups); and over to decision-making processes in other nations or groups of nations.[6]

The resulting expansion in the configuration of policy claimants produces uncertainty and conflict, greater complexity, and protracted delay, since the formerly stable sets of actors and procedures no longer control the parameters of policy-making in this issue area. Crisis politics transforms existing arrangements into new configurations, and those gaining access to policy-making during the upheaval are likely to remain, even after issue attention wanes, because these newly enfranchised insiders quickly develop their own stakes in policy outcomes. These new policy-making configurations are likely to be less exclusive and more permeable than were their predecessors. They are probably rather inchoate, more susceptible to momentary political pressure. The issue network conceptually is much more than the subgovernment, but it also is much less than mass politics.

Paul Sabatier probably has done the most to help make analytical sense of this amorphous reality.[7] An Advocacy Coalition Framework (ACF) developed by Sabatier conceptualizes policy-making as a function of common, but not necessarily coordinated, advocacy by loose coalitions of actors competing with one another for policy dominance:

> An advocacy coalition consists of actors from a variety of governmental and private organizations at different levels of

> government who share a set of policy beliefs and seek to realize them by influencing the behavior of multiple governmental institutions over time.[8]

The ACF explains the processes of how an advocacy coalition brings about policy change and evolution over time:

> First, advocacy coalitions within the subsystem attempt to translate the policy cores and secondary aspects of their belief systems into governmental programs. Although most programs will involve some compromise among coalitions, there will usually be a dominant coalition and one or more minority coalitions... The second process is one of external perturbation, that is, the effects of system-wide events– changes in socioeconomic conditions, outputs from other subsystems, and changes in the system-wide governing coalition– on the resources and constraints of subsystem actors.[9]

Policy change over time is a function of three sets of factors: the interaction of competing advocacy coalitions within a policy subsystem; changes external to the subsystem (socioeconomic conditions, system wide governing coalitions); and effects of stable system parameters (basic social structure, constitutional rules) that act as constraints. "Changes in the core elements of public policy require the replacement of a dominant coalition by another, which is hypothesized to result primarily from changes external to the subsystem."[10]

DEFINING PROBLEMS AND SETTING POLICY AGENDAS

A central dynamic of the ACF, and the central political struggle between competing advocacy coalitions, is over the definition of the core policy direction and the setting of policy agendas. In this regard, Sabatier is following a well-established literature:

> Political conflict is not like an intercollegiate debate in which the opponents agree in advance on a definition of the issues. As a matter of fact, the definition of the alternatives is the supreme instrument of power. He who determines what politics is about runs the country, because the definition of alternatives is the choice of conflicts, and the choice of conflicts allocates power.[11]

The dynamics by which problems get atop the agenda of political action, and where alternatives are defined by and for policy-makers, powerfully shape policy formation in any political system. Thus, to study policy formation is to study policy problems. "Much of what government does represents efforts to deal with contradictory and conflictual definitions of and solutions to societal problems."[12] Not all problems are perceived to be alike by policy-makers, attentive interests, or the mass public.[13]

What is more, not all problems get on the agenda of policy action. Policy-makers are not always faced with an obvious problem and they often have to identify and formulate the problem.[14] This is the guts of politics, a constant struggle among interests to get their respective problems onto the agenda of action, or, alternately, seeking with equal ardor to keep some matters out of the public policy realm. Such conflicts come in many guises. Some problems seemingly never get onto the agenda of government action because prevailing social values, ideologies, or norms keep them off. For others, such as a pluralist conception, interested publics pushing for access onto the agenda seems the appropriate description of reality. Regardless which image holds in any particular situation, agenda-setting is a process shaped by political conflict.

Although the nature of problems and the institutional superstructure of any system greatly shape the ways that issues get onto the agenda for action and, once there, how they are dealt with by policy-makers, such factors certainly are not deterministic. Politics are motivated by self-interest, shared ideals, values, or whatever still matters in propelling problems through and past the obstacles that keep the agenda for action from getting overloaded. Someone has to care passionately if a perceived problem is to be something more– the focusing event or crisis pluralists long have pointed to as a factor in agenda-setting explains why some groups succeed and others do not.

Some of the factors that propel problems onto the agenda for action obviously are exogenous: natural catastrophes, unanticipated human events, and technological or ecological changes.[15] Of more immediate importance are the intense interests and strategic actors whose support for or hostility to issues matters most immediately in structuring the formal agenda for action. In the US the picture is of many actors and interests competing for access and influence from an abundance of strategic positions. Given the features of the formal system and the diversity within the US, it is no wonder that studies of agenda formation tend to take as their points of departure the pluralist image of competition among organized interests, both in and out of government.

There are many different access points and one institution or jurisdiction rarely controls a given policy domain.[16] Policy communities serve to knit this fragmented system of governance together. Whether such a community is depicted as a "subgovernment,"[17] "issue network,"[18] or

"advocacy coalition,"[19] within each there are assumed to exist "actors from a variety of public and private organizations at all levels of government who share a set of basic beliefs (policy goals plus causal and other perceptions) and who seek to manipulate the rules of various government institutions in order to achieve those goals over time."[20] At the nub of politics is, first, the way in which the public participate in the spread of conflict, and second, the processes by which the unstable relation of the public to the conflict is controlled.[21]

Political conflict is a tension between those seeking to expand participation in a debate and those working to minimize participation. "Public policies are made through the interaction of the images which are used to explain them and the institutions which are able to claim jurisdiction over them."[22] Policy-makers attempt to manipulate both of these factors in order to achieve their programmatic goals. The policy struggle is over both the definition of issues and control over the processes and arenas within which decisions are made. Having formal jurisdiction is not enough.

Several studies of policy formation bear out this point forcefully. Christopher J. Bosso, examining forty years of US federal policy toward chemical pesticides, concludes that perhaps "the most powerful change in the pesticides policy case was its being redefined as an environmental matter; loss of the power to define the issue was probably the most critical factor causing the decline of the pesticides subgovernment."[23] In a lengthy study of postwar federal employment policy, the point was made that:

> Of the three factors (interests, institutions, and ideas), none had a more substantial and direct impact on charting the direction and framing the content of employment policy than ideas... Institutions may have blocked certain alternatives, shaped the packaging of programs, influenced the timing of changes, and led to implementation failures. The political activities of organized interests (or lack of them) may have influenced the level and distribution of program benefits and circumscribed the role of employment programs in the economy. But it was the subjective predispositions that policy makers brought to their task and their receptivity to the ideas of experts and reformers that had the greatest influence on the substance of policy.[24]

These case studies are given critical empirical support in an important comparative work that looked at several policy areas (smoking, pesticides, and nuclear power) over time and conclude that "failure to control the images

associated with a policy can lead to loss of control over the policy itself, even when it appears to be firmly within the institutional jurisdiction of influential groups all of whom favor the current direction of public policy."[25] Control over problem definition is key to policy formation.

The studies unearth strikingly similar long-term issue dynamics. In most cases, policies were formulated originally under conditions of relatively limited participation and mostly positive public perceptions of the issue's "image." The result is subgovernment dominance, an irony in that most of these policy areas studies begin with the late 1940s and early 1950s, when pluralism emerged as the guiding paradigm of US politics. What follows are efforts by defenders of the status quo to manipulate both the image of the policy area and the venues for policy formation, particularly as more and ever-diverse interests, both in and outside government, recognize a stake in and demand to take part in decision-making. In each case, and usually in the early 1970s, the subgovernment defending the status quo crumbles or becomes distended, and in its place emerges a broader, more permeable, and far more inchoate "sloppy hexagon,"[26] "issue network,"[27] "policy community,"[28] or "advocacy coalition."[29] This relentless socialization of conflict eventually produces great policy fluidity and, even stalemate, at least until the next time there occurs an imbalance among public perceptions and the array of political interests.[30,] Whether it be the "intrusion" of environmental perspectives into the debate over pesticides, of health views in the cases of smoking or nuclear power, or the battle over core values on an array of social policies, whoever best manipulates the image of an issue has an edge in the battle over the agenda for action and, as a result, an advantage in policy formation.

In addition, the studies share a focus on configurations of shared policy or issue interests, not on mass behavior, the rough structure of the economy, class or other elite backgrounds, individual leaders, or any single institution. As Sabatier argues, "one of the clearest conclusions to emerge from the policy literature is that understanding the policy process requires looking at the intergovernmental policy community or subsystem– composed of bureaucrats, legislative personnel, interest group leaders, researchers, and specialist reporters within a substantive policy area– as the basic unit of study."[31] This perspective has practical and normative implications. In tracing policy configurations, the studies of policy formation conclude that, at least in the US, the nature of the policy agenda and the direction of public policy, usually is in greater flux than one might assume by looking at class structure, ideologies, or institutions alone. There is fluidity amidst seeming stability.

> Pluralism, then, is not invariably conservative. The existence of multiple venues certainly makes it difficult to rout the old order. But it also allows new policy ideas to find niches within which to flourish. Because powerful economic interests cannot normally dominate all venues, they can lose control of the policy image that protects them if they do not also control policy images. As images change, so does the possibility for dramatic policy change contrary to the will of those previously favored by governmental arrangements.[32]

As Sabatier notes with respect to the advocacy coalition concept, core values are powerful forces. In the US, core values are often tied to an ardent faith in the "invisible hand" of the market, making politics subordinate to the private commercial sector. So powerful are market values, many of which are buttressed legally by the US Constitution, that they create the conditions for a "privileged position of business" in any political debate. In any economic system based on private enterprise "a large category of major decisions is turned over to businessmen, both small and larger ...businessmen thus become a kind of public official and exercise what, on a broad view of their role, are public functions."[33] Whether one agrees entirely with this conclusion there is little doubt that the sanctity of the free market is a cornerstone of the American value system.

The national ideology of free-market capitalism is so potent that anyone who suggests real alternatives is labeled quickly a "radical," an image that ultimately exiles advocates to the margins of mainstream policy discourse. A market regime itself simply is what it is– impersonal, imponderable, and immutable. The potency of free market values can be seen elsewhere as in the case of the US airline industry, which is regulated only to the degree that competition is kept honest and consumers are protected from fraud or dangerous practices.[34] Of course, the industry itself is never to be nationalized, an option certainly exercised for openly non-market reasons in more than a few other nations. In fact, the US airline industry was deregulated to allow the market to operate more efficiently. But deregulation could go only so far, since unchecked competition might lead to oligopoly. Thus, both nationalization and total deregulation are seen as paths to monopoly control, one by government, the other by big business, so the range of acceptable policy debate lies somewhere in between. In this sense the notion of positive and negative construction (or "image") suggested by Baumgartner and Jones is useful: the "airline industry" is in an advantaged position save for when government is brought in to referee the rules of

competition or to ensure that customers are not getting gouged. Otherwise, let the market reign.

So where does all of this discussion leave the policy elites, interest groups, and other political actors that are presumed to be central players in any conflict over policy definition? It is argued that all political elites pursue variations on strategies of expanding ("socializing") or narrowing ("privatizing") conflicts.[35] One study, which compares US and French nuclear power policy-making, shows that how respective elites pursue those strategies depends on the system itself:

> The complicated institutional structures of the United States and the autonomy of a number of governmental authorities allowed opponents many opportunities to shift the venue of the debate to one where they could be successful. In France, on the other hand, a determined set of governmental agencies use a streamlined set of institutions and procedures in order to keep consideration of nuclear power restricted to a small set of experts with a shared interest in the growth of the program.[36]

If policy definition is contextual, then elites, interest groups, and the mass media are not free to act in any way they want. If "the course of conflicts may be partially understood by reference to the ability of groups to establish their definition of the situation as the appropriate one,"[37] the freedom of groups to maneuver is remarkably constrained by public values and by the system of governance. Policy elites, interest groups, and media organizations play key roles in defining problems and setting agendas. There also is more than a little fighting among elites and groups over whose alternative construction of reality will emerge. But none of this takes place in a vacuum.

All of this comprises what might be called a "polity-centered" approach to problem definition.[38] Societal characteristics and cultural values converge with existing structural and political conditions to create the contexts within which political actors jockey to promote competing problem definitions and formulate public policy. These conflicts, in turn, influence dominant values and policy processes. "As politics creates policies, policies also remake politics."[39] It is an image of constant if not seamless change that challenges scholars to rethink more static models of policy-making and to revisit such factors as culture, socioeconomic factors, institutions, and historical conditions– the contexts within which all policy actors, including organized interests, are forced to operate when setting policy agendas and formulating public policies.

COALITIONS AND SPACE POLICY

This chapter opened by noting that for much of the past decade funding for NASA has been comparatively static despite the fact that many of the groups that have been involved with and profited from the US space program, such as defense-related industries and labor unions, are considered to be among the most politically influential. As the above analysis suggests, simply to state that certain powerful groups are in support of US space policy glosses over their varied and even conflicting priorities. In other words, not all participants in the space policy arena see the space program in the same way.

This is a relatively recent development. For much of the 1960s and 1970s, being "pro-space" meant being "pro-NASA," or more precisely, supporting expensive, large-scale, technologically intensive endeavors like Apollo. Some policy-makers during this period did try to separate space policy from NASA, portraying themselves as supportive of government sponsored space activities in principle, while simultaneously criticizing specific NASA projects like the Apollo Moon landing. Arkansas Senator J. William Fulbright, for example, frequently spoke of an "American destiny in space," but was a trenchant critic of what he saw as an Apollo "crash program."[40] Arizona Senator Barry Goldwater mounted a similar effort from the political right, arguing that all funding for the lunar project ought to go for space-based defense.[41] These efforts to "finesse" the space issue never seemed to take root. As far as most policy-makers– and the vast majority of the mass public– were concerned, there was only one viable vision of the US civil space program, and that was NASA.

This near unanimity was a result of the fact that, beginning almost immediately after the launch of Sputnik in 1957, US space policy became defined as a Cold War issue. A number of factors, including widespread fears of Soviet achievements in space, the Democratic Party's efforts to take advantage of an incident potentially damaging to the Eisenhower Administration, and Senate Majority Leader Lyndon B. Johnson's desire to ride the satellite issue to the White House, combined to transform the fledgling US space program into one more area of American-Soviet competition. This particular definition meant that NASA had to emphasize projects that demonstrated US parity with, if not superiority over, the Soviet space program. Apollo fit this perceived need quite nicely. The relationship between NASA and external groups comes very close to the interest group model.

By the 1980s, in contrast, space policy had become more complex. To begin with, the relevant technologies had matured to the point where they

could serve a number of military, commercial, and scientific ends, and as a result, organized interests representing each emerged advocating their varied interests. In addition, the officials in the Reagan Administration actively sought– to a degree not seen since the Kennedy-Johnson years– to incorporate space into their larger policy goals and vision of government. This latter point is particularly important. Because, for example, they regarded national defense as one of state's primary duties, policy-makers were willing to accept a very large role for DOD, including the creation of an entirely new bureaucracy (US Air Force Space Command) and very large increases in public spending such as that ensued with the Strategic Defense Initiative (SDI).[42] Indeed, by the end of Reagan's second term, DOD's budget for space operations was larger than NASA's.[43]

Consistent with their free-market philosophy, Reagan Administration officials at the time adopted a very different approach with regard to their other major policy objective, namely the expansion of space commerce. Here, the emphasis was on encouraging private sector initiatives, while working to reduce the role of government, which means, in effect, the role of NASA. One of the more visible outcomes of this approach was the development of the commercial launch industry. Ever since Sputnik, launching objects into space had been the exclusive province of government agencies like NASA. President Reagan's 1986 decision (made in the wake of the Challenger accident) to ban commercial payloads from the Space Shuttle opened the way for private firms to begin offering launch services. By the mid-1990s, the majority of space launches of satellites, taking place in the US and throughout the world, was being conducted by the commercial sector.[44]

The 1980s marked the start of the International Space Station (ISS). Initially known by the name Freedom, it was proposed by Reagan during his 1984 State of Union address. Albeit technically a joint project involving today the space agencies of Russia, Europe, Japan, Canada, Italy, and Brazil, it is NASA that plans to provide the largest share of hardware and financing. The ISS is expected to provide a platform for scientific research and commercial development.

The net effect of these changes in the US space program has been to drastically alter the relationships between the federal government and space policy stakeholders. Stated simply, to be "pro-space" can now mean one of a number of different things. Unlike the Apollo era, it is now politically feasible to be "pro-space" and "anti-NASA," or even anti-government (i.e., pro-market). Thus, rather than a "space lobby" of the sort envisioned by the traditional interest group literature, the US space program is confronted by a variety of advocacy coalitions:

Business in Space. This advocacy coalition, which is focused largely on material benefits, is made up of those interests who regard the space environment primarily as a venue for making profit. It includes the commercial space sector and their political supporters in the US Departments of Transportation and Commerce, and parts of NASA. The group is also closely aligned with the Republicans on the House Space and Aeronautics Subcommittee and the Senate Commerce, Space, and Transportation Committee. Not surprisingly, this coalition is strongly committed to the ideal of free market capitalism, and regards government involvement in space as a constraint to the commercial development of space.

National Defense, "High Frontier." Driven largely by national security concerns, this advocacy coalition is made up of the relevant parts of the DOD (e.g., Ballistic Missile Defense Organization and the Air Force Space Command), private defense contractors with whom DOD works, and the US State Department. It receives additional support from the House and Senate Armed Services Committees as well as prominent conservative and other pro-military organizations and individuals.

Nee-Apollo, "Human Destiny." This advocacy coalition is comprised of "true believers" who call for the settlement of the Moon and Mars. It is focused primarily upon purposive benefits to society and is made up of the so-called NASA (and NASA associated) "old hands" of the Apollo era (e.g., the late Wernher von Braun and Carl Sagan), and a number of space-based professional and grass root organizations, such as the American Institute of Aeronautics and Astronautics, American Astronautical Society, International Astronautical Federation, National Space Society, Planetary Society, and Mars Society. Support for this coalition's view is also scattered throughout other US federal agencies, universities, and parts of the public.

Science in Space. The relationship between research scientists in industry, academia, and government (and their allies in Congress and the federal agencies) and the US space program has always been tense. Even though federal funding for all areas of science and engineering increased markedly after Sputnik, many in the American scientific community came to view NASA, and

especially the human spaceflight program, with some suspicion. Many scientists, for example, strongly opposed the Apollo program, arguing that its excessive costs would divert resources away from other, more scientifically justified projects.[45] Their protests had little impact, however, since these groups had not yet learned how to organize for political action. By the 1980s, however, professional associations representing virtually every scientific discipline had become politically involved.[46] This coalition seeks a mix of material and purposive benefits. In some cases, such as the Hubble Space Telescope, these groups have persuaded Congress to fund large-scale space science programs.[47] They have also, with less policy success, publicly criticized other NASA projects like the ISS.[48]

It is interesting to note how these different coalitions relate to NASA. As noted above, during the 1960s and 1970s, the Agency basically was the space program, and for the "neo-Apollo" group this is still basically true. Like the "pro-space" lobby of the past, these organizations and individuals generally call for large increases in government spending on space exploration, and protest every time NASA's budget is cut.[49] Not surprisingly, they strongly support such large-scale initiatives as ISS and a government-sponsored human mission to Mars.[50]

Some coalitions, on the other hand, tend to regard the Agency as something of a competitor, if not a direct adversary. The "business in space" group is the most notable in this regard. Advocates of expanded space commerce have, since at least the mid to late 1980s, viewed reducing NASA's operations as a necessary precursor to their own goals.[51] The emergence of the commercial launch industry, for example, became possible only after President Reagan ordered the Agency (following Challenger) to stop carrying commercial payloads at subsidized rates. There are similar tensions regarding the Space Launch Initiative (SLI), a multi-billion dollar program in which NASA awards money to private firms to encourage development of new launch vehicles (at least one of which, it is hoped, can serve as a successor to the present Space Shuttle). As its critics see it, SLI represents just another case of unwarranted government intervention.[52] In short, the private sector believes that to be "pro-space" means decreasing the role of NASA so as to clear the way for more commercial activity.

With regard to the defense group, the rivalry is less direct. Although the National Aeronautics and Space Act explicitly prohibits NASA from engaging in military space activities, there have been occasions where the jurisdictional lines have been blurred, setting up a potential conflict over resources. In the early 1990s, for example, DOD's SDI Office (SDIO) began

testing a variety of new and rather exotic technologies. Experimenting with the first generation of light-weight materials for satellites, SDIO launched a probe called Clementine to the Moon (the first US lunar mission since Apollo) and the asteroid belt.[53] Even more ominous, from NASA's perspective, were the 1993 test flights of the DC-X, a prototype for a fully reusable launch vehicle.[54] SDIO maintained that these technologies were directly related to ballistic missile defense, but there was concern among some in the civil space program that SDIO might appear to be more technologically innovative than its civilian counterpart.[55]

CONCLUSIONS

In stark contrast to the position of dominance it enjoyed at the height of the Apollo era– in what is best thought of as a single, unified space program– NASA's role in the far more complex policy environment of the post-Apollo era is to serve as a sort of "broker" among all of the competing coalitions. This is also the case internal to NASA as its component offices align themselves with one coalition or another of them. The role of a "broker" for administrative agencies is to advocate more centrist positions than their interest-group allies.[56] In NASA's case, it may not always be clear what constitutes a "centrist position." To begin with, some of the coalitions with which the Agency must deal can hardly be considered "allies." Some members of the "business in space" group, for example, would be perfectly content if NASA was eliminated altogether.

Moreover, the requirements of most large-scale R&D programs– such as a permanent base on the Moon or human missions to Mars– can best be characterized as requiring a high level of resource commitment over decade-long time periods. These types of programs usually do not respond well to attempts at "brokering" between coalitions. However, NASA does make the attempt by developing commercial plans for human spaceflight (e.g., Space Shuttle privatization and ISS commercial development plan), by commissioning "studies" of Mars missions, and by demonstration projects of the component technologies needed to support Mars missions.[57]

PART TWO

SPACE POLICY FORMULATION AND IMPLEMENTATION:

POLICY ACTORS AND INSTITUTIONS

4
PRESIDENTS AND SPACE POLICY

Linda T. Krug*

INTRODUCTION

On 25 May 1961, United States (US) President John F. Kennedy unveiled his plan for a unified space program. He stated, “Now it is time to take longer strides, time for a great new American Enterprise, time for this Nation to take a clearly leading role in space achievement which in many ways may hold the key to our future on Earth.”[1] On the eve of the Challenger explosion in 1986, President Ronald Reagan also spoke of the space program. “We’ve grown used to wonders in this century,” he stated. “It’s hard to dazzle us. But for 25 years the United States space program has been doing just that. We’ve grown used to the idea of space and perhaps we forgot that we’ve only just begun. We’re still pioneers.”

In the 25 years separating these statements, American ingenuity and imagination has moved from the science fiction fantasies of space rockets to the reality of space probes, from Star Trek to “Star Wars,” from a great national enterprise to a renewed pioneering spirit. Not only have our physical actions, like the launching of the Space Shuttle or walking on the Moon, made such endeavors possible, but so too have our words. Indeed, where our actions may have failed or disappointed us, our words have continued to carry us forth. When the Soviets beat us into space, for instance, Kennedy sought to renew us: “We have a long way to go in the space race, but this is the new ocean and I believe the US must sail on it.” And when the Challenger exploded, Ronald Reagan reminded us that it is “...all part of taking a chance and expanding man’s horizons...the future doesn’t belong to the fainthearted, it belongs to the brave.”[2] As a symbol using, symbol misusing, and symbol-making people, our words function not only to impart information, but also to create images of self and society.

Exactly how US Presidents have conceptualized and talked about the space program is a subject worthy of exploration, for it is in their talk, in their words and images, that clues as to why the US space program and resulting space policy is formulated as it is. Presidents, of course, are not the only players in the space policy arena. Advocacy coalitions, presidential advisors,

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congressional representatives, and the space bureaucracy, to name a few, also try to exert their control over how space policy will be defined and formulated. Yet, it is the President who, through his "unique constitutional power" to speak directly to the public,[3] has the responsibility of leading the nation on matters of public policy. Indeed, "if a President fails to execute this "rhetorical power," he will be a failed President, and the country will be steeped in policy confusion."[4] The goal of this chapter is to explore the role of Presidents in articulating US space policy and to evaluate their success in making that policy a reality. To provide an appropriate context, this chapter first turns to a description of the "rhetorical Presidency" and then to a review of the literature surrounding Presidents and space policy.

PRESIDENTS AND RHETORIC

A rhetorical interpretation of the modern Presidency is based on the assumption that communicating has become one of the most prominent features of presidential governance. With the modern Presidency "a week scarcely goes by without at least one major news story devoted to coverage of a radio or television speech, an address to Congress, a speech to a convention, a press conference, a news release, or some other presidential utterance."[5] In addition, "What ever doubts Americans may now entertain about the limitations of presidential leadership, they do not consider it unfitting or inappropriate for Presidents to attempt to 'move' the public by programmatic speeches that exhort and set forth grand and ennobling views."[6]

So rhetorical is today's Presidency that many scholars now refer to the Presidency as the 'public Presidency': "...a strategy whereby a President promotes himself and his policies...by appealing to the American public for support."[7] This suggests that the Presidency is a "plebiscitary office– one deriving power from public support."[8] In the modern age Presidents talk to us more than ever: "presidential speechmaking– perhaps presidential communication in general– has now become a tool of political barter..."[9] In many ways, "we are witnessing the evolution of the 'new presidential' rhetoric that differs in both form and content from that of only twenty years ago."[10] In fact, "...the modern Presidency is more rhetorical than previous presidencies, more heavily conditioned by media exposure, more attuned to image making, and more easily included to translate policies and decision-making processes into media events."[11]

Indeed, so enamored have modern Presidents become with speaking that they and their publics increasingly believe that a good leader is one who "consistently exhorts in the name of a common purpose and a spirit of idealism."[12] Speaking no longer merely attends the process of governing, but

rather, has become synonymous with governing. This idea is reflected in a study of the symbolic Presidency: symbolism, in this regard, "forms a large and important part of political activity...control of the symbolic actions of government is as important as the control of its tangible effects."[13] People tend to compartmentalize the Presidency, "separating out the symbolic from all the other things the President supposedly is or does. So we speak of a President's successful image at the same time we speak of him managing the economy."[14] Other scholars believe that this dichotomous interpretation is flawed as the two aspects, symbolism and rhetoric, cannot be separated: "...Presidential symbolism and rhetoric shape public and official perspectives of what are the legitimate roles of government."[15]

The link between rhetoric and presidential governance dates back to the notion that the power of Presidents was the "power to persuade."[16] Presidential "words were the basis for official action or inaction, and for the public's feeling of optimism or pessimism, content or discontent, about the course of political life."[17] Murray Edelman, in *The Symbolic Uses of Politics* notes "it is the talk and the response to it that measures political potency."[18]

Political pundits and campaign managers have commented on the importance and propensity of public discourse. In typical campaign fashion "a candidate's image can make him or break him. If he can convince the people that he understands and will respond to their wishes– as Franklin D. Roosevelt and Dwight D. Eisenhower were able to do– he can be unbeatable. If instead he appears aloof and cannot communicate with the citizens, he is headed for defeat."[19] Similarly, "modern presidential leadership entails persuasion, and it matters greatly who says what to whom, when, why, how, and with what evolutionary political results."[20] President Bill Clinton won the White House, in part, because of the jeremiadic vision presented in his acceptance speech: "...articulated the ancient truth, spoke to people's need for optimism, justified his life-long pursuit of the Presidency, and challenged each citizen to assume more personal responsibility for the condition of life in America."[21]

Presidents, too, have recognized the significance of their own voices. In a speech designed to end the national railroad strike, Harry S. Truman asserted that his powers amounted to bringing in people "and persuading them to do what they ought to do..."[22] Jimmy Carter, believing that his Presidency was in trouble in 1979, assembled his advisors for the explicit purpose of seeking oratory to move an entire nation.[23]

In the estimation of presidential scholars, rhetoric is more than a tool used by an individual President to accomplish some particular goal; it actually comprises the essence of the modern day Presidency. Changes in the doctrine of presidential leadership, coupled with the rise of the mass media and

contemporary methods of political campaigning, have produced the belief that a President is an effective leader only when speaking.[24]

So entrenched has the notion of public discourse become to the modern Presidency that it is now virtually impossible to talk about the Presidency without also talking about presidential discourse. "Contemporary Presidents have used... distinct genres of discourse in which they use language that differs from that used by candidates, corporate executives, social activists, and religious leaders even though it evidences elements of each."[25] And yet "Presidents...speak in ways that are characteristically presidential."[26] As a result, studies of the Presidency now address the issue of presidential rhetoric.[27]

PRESIDENTIAL SPACE RHETORIC

In the last ten years, a growing number of scholars have looked specifically at how Presidents have articulated their thoughts about the space program and with what results. Although these scholars come from different perspectives, their conclusions are similar: when it comes to setting US Space Policy, no President has enjoyed singular success or failure. Eisenhower, for instance, sought to build a balanced space program, one that held science on par with exploration, and yet was ousted from office for failing to move the program forward fast enough. Kennedy is always credited with single-handedly shaping the space program with his challenge to go to the Moon, but it is clear that he did so as a matter of politics not exploration. Lyndon Johnson was an enthusiastic proponent of space exploration, but as President he labored only to keep Kennedy's program alive. Richard Nixon ushered in the era of space use with support of the Space Shuttle, but the record shows that he did so against the advice of his cabinet. Reagan sought to forge a unified vision of space exploration, but was split between militarization and privatization. George Bush (89) fought hard for a plan that would establish a space station, a permanent Moon base, and a manned mission to Mars by the end of the 1990s, but he was unable to convince anyone of its importance. Clinton, too, was keenly interested in investing in the arena of space, but as the 1990s wore on he sought to distance the White House from the "Faster, Better, Cheaper"[28] philosophy of NASA. And, Bush (01) is so beset by other issues of importance, such as the global war on terrorism, that he has delayed the formulation of a space policy.

Presidents have spoken so many words about the space program, yet today we have no lasting, compelling vision of space exploration, no coherent space policy. Save for the directive to land a man on the Moon, there has been no "reasonably well thought-out-plan of action to achieve a relatively

well-defined goal to which both a congressional majority and the President agree."[29] Understanding why our Presidents have failed to forge a coherent national space program and space policy requires an understanding of five key factors: level of presidential interest; limits inherent in presidential interest; lack of a coherent vision (e.g., the inability to blend space exploration with space use); shift from primary space policy to ancillary space policy; and decline of the power Presidency.

Level of Presidential Interest

Until recently, space activists and observers have assumed that the more interest a President demonstrated toward the space program, the more likely he is to be supportive of space activities. This assumption was based on the belief that the executive branch exercised control over the legislative one, and on the empirical evidence of Kennedy's vision to land a man on the Moon. The President's enthusiasm was considered to be the primary factor in formulating and implementing a productive, forward-looking space program,[30] and President Kennedy's ability to formulate a clear national commitment gave credence to the belief that it could be repeated by another President in similar fashion.[31] As a result, nearly every accounting of presidential action regarding space discusses the level of that President's interest. If there was an overall "presidential interest scoreboard," it would look something like this: high marks for Kennedy, low marks for Carter, Gerald Ford, and Bush (01), and middle-range marks for Eisenhower, Nixon, Johnson, Reagan, Bush (89), and Clinton. The following summaries of presidential interest support this assessment.[32]

Eisenhower's role in US space policy could be characterized as "that of a reluctant participant in a highly public program of research and development that had all of the earmarks of a race but that the participant himself resolutely defined as a non-race."[33] President Eisenhower was very interested in promoting a balanced, moderate program. He was not interested in chasing after the Soviets. Simply put, Eisenhower was a strategist and a planner. As a former general, he was interested in looking at the "bigger picture" and in moving only after careful study and consideration. Even as the public began to contract "space fever," as the result of the Soviet launching of Sputnik, Eisenhower steadfastly refused to "...ride off in all different directions at once."[34] Rather, he stood firm and pushed for a more reasonable framework within which to view space exploration activities.

Interestingly, when Kennedy entered the White House, space exploration was not very high on his personal or political agenda. Some have

even asserted that space was not on Kennedy's policy agenda at all.[35] Even though Kennedy told supporters during his bid for the Presidency that "we are in a strategic race with the Russians and we have been losing,"[36] he did not produce any program of space exploration during his first few months in office. It was only after the failed attempt to overthrow Fidel Castro of Cuba combined with the Soviet's successful launch of Yuri Gagarin into Earth orbit that space became a priority. Following these events, Kennedy instructed his Vice President, Lyndon Johnson, to determine "whether there is any program now, regardless of cost, which offers us hope of being pioneers in a project...which could put us first in any new area."[37] Eight days later, Johnson returned with the answer: "The US can, if it will, firm up its objectives and employ its resources with a reasonable chance of attaining world leadership in space during the decade."[38] Still, Kennedy was the one to ask the nation to "take longer strides" and to sail "on this new ocean," and so it is he who is considered by many to be responsible for the rise of our modern space program.

President Johnson was not new to the space race at all. In 1957, when Soviet Sputniks created a national furor, he was the chair of the Senate Space Committee and a leading critic of the Eisenhower Administration's response. "It is not our technology that has failed, [but] our leadership," Johnson stated in a speech delivered in 1960.[39] By the time he became President, however, his position on the space race had softened considerably. "It was really a mistake to regard space exploration as a contest which can be tallied on any box score," he stated during a press conference.[40] Instead, he began to speak rhetorically of cooperation: "As [man] draws nearer to the stars, why should he not also draw nearer to his neighbor? As we push even more deeply into the universe, we must constantly learn to cooperate across the frontiers that really divide Earth's surface."[41] As his interest shifted toward other matters, such as the building of his "Great Society," his interest in space began to wane. One of the most striking features of Johnson's memoirs on his Presidency is that he "devotes only seventeen of six hundred pages to a discussion of space. And of those seventeen pages, only three describe space policy during his Presidency."[42]

Nixon, like Johnson, was not new to the space program or to the politics of space. He was at Eisenhower's side when the news of Sputnik splashed across the front page of every paper in the nation. He was the first member of Eisenhower's administration to speak out about the Soviet launch, warning that "we could make no greater mistake than to brush off [Sputnik] as a scientific stunt..."[43] However, while the astronauts intrigued him, inviting them to the White House after every space event and exploiting them for his political purposes, as President he did not seem to exhibit the same enthusiasm for or expansive commitment to the space program as did Johnson

or Kennedy.[44] Nixon was responsible for approving the Space Shuttle, but at the same time he was also responsible for killing public interest in the program. He took away our pioneering posture and transformed our need to explore the heavens into something as ordinary as going to school. Whereas a decade earlier, the program had been elevated to a special position in life, now it was no different than education, housing, or any other governmental concern. Space became utilitarian rather than exploratory and pioneering.

Of all the Presidents involved in the US program of space exploration, Ford contributed the least. Under normal circumstances, Ford would have brought the vice presidential experiences as head of the President's Space Council to bear. Time, however, did not afford him the luxury of such experience, and he was forced to scramble to come to terms with the history of the space program. As it turned out, Ford spent much of his tenure as President trying to move the nation beyond the crisis of Watergate. His pardon of Nixon was indicative of his desire to get the country moving again, and so too was his rhetoric of space exploration.[45] Other than giving a handful of remarks about Skylab and the US-Soviet space link-up (Apollo-Soyuz Test Project), Ford did little for the program. "In Mr. Ford's subsequent autobiography, *A Time to Heal,*...he does not refer by index subject, name, word, or picture on any page to American space affairs before or during his Presidency."[46]

When Carter ran for the Presidency, he did so as an outsider. He wanted the American people to know that he was not like the Washington insiders, that he had a fresh way of looking at political and societal events, and that he was untainted by big money or big interest. True to his word, Carter went out of his way to "keep in touch with the American people."[47] He worked in his shirt sleeves, walked instead of driving, visited people in their offices, held relaxed televised fireside chats, sent his daughter to public school, and lobbied for a space program that could deliver a public dividend. As Carter presaged a theme of "unmanned scientific exploration and practical applications of existing technology,"[48] the wonderment of space exploration emphasized by earlier Presidents dropped out of...vision altogether. "I'm interested in the shuttle program," Carter noted, because "it's going to be a much cheaper means by which we can perform our very valuable flights in space and still return the costly vehicle back to Earth."[49]

Following Carter, it is no wonder that when Reagan was elected President, NASA officials breathed a sign of relief. For eleven years, the period of time that had elapsed since the first astronaut stepped onto the Moon and support for the space program began to diminish, NASA officials had been forced to engage in incremental and ancillary politics. With dismay, they watched as the final three Apollo missions were scrubbed; as the three-

tiered project of space station, space shuttle, and Moon base became the Space Shuttle; and as interest in a mission to Mars was relegated to the back burner of the policy agenda.

Reagan, however, appeared to be a true believer in space: "Like President Kennedy before him, Reagan seemed genuinely entranced by the space program."[50] In terms of concrete decisions and actual deeds, Reagan accomplished little for the space program. He did come close to making an Apollo-type decision by calling for a manned space station, and he did authorize NASA to build a replacement shuttle for the lost Challenger. Also, he got us thinking about "space shields" (i.e., Strategic Defense Initiative). However, what Reagan did for the program was to revitalize itrhetorically. "The challenge of pushing back frontiers is part of our national character. As we face the vast expanses of space, let us recapture those stirrings in our soul that make us Americans. Space, like freedom, is a limitless, never ending frontier on which our citizens can prove they are indeed Americans."[51] Reagan created a vision of a US space program "standing tall" and in doing so, brought renewed energy and a new vitality. Rhetorically, space policy shifted from a focus on utilitarian aspects, emphasized by Nixon and Carter, to reflect the themes of space exploration and "pioneering the space frontier."[52]

As head of the President's Space Council and as a presidential candidate, Bush (89) supported Reagan's space policy. The neo-Apollo advocacy coalition of NASA officials and space enthusiasts hoped that Bush would do something to carve out a major commitment to space. On 20 July 1989, during a celebration commemorating the twentieth anniversary of landing on the Moon, Bush proposed the Space Exploration Initiative (SEI). This initiative was a long-range continuing commitment including development of Space Station Freedom– "our critical next step in all our space endeavors," a Moon base– "back to stay," and a manned mission to Mars.[53] After this initial rhetoric, Bush never intervened on behalf of the space program again. "Perhaps his support for the venture had been weak from the beginning, or perhaps he decided it wasn't worth investing time and effort in something which may not show results until thirty years hence."[54] Whatever the reason, Bush's eventual political inaction did lead some observers to suggest that Bush was a "space advocate" in the same sense that he was the "environmental President" or the "education President."[55]

Clinton's interest in the space program was moderate at best. Two issues captured his attention early in his tenure, the redesign of Space Station Freedom and international cooperation in the space station project. How he dealt with both of these issues set the stage for how his administration would come to view the space program as a whole: as an economic investment. For instance, speaking at a news conference in June of 1993 Clinton stated, "I

think it would be a mistake, after all the work we've done, to scrap the space station... We're going to be able to get more people to come in and invest with us, and we're going to have to make some very tough management decisions at NASA to get that done."[56] Two months later, Clinton echoed the same theme in an interview with newspaper editors: "It is very important to maintain our leadership in space technology. It's very important in terms of new partnerships with Russia...But most important, it's a big economic boom to us. If we get out of this [space station] the Europeans will move right in, take this over and have a lot of those high wage jobs that Americans should have."[57] For Clinton, the issue was "the economy, stupid" and that adage applied equally to all he dealt with. In 1996, Clinton did release a rather substantial "fact sheet" detailing how the government could stimulate economic and business activity from space programs.[58]

John Logsdon adds another dimension to the level of presidential interest when he asserts that a President's attitude toward space is dependent upon his "judgment of the program's usefulness as an instrument for projecting an image of US leadership to a global community and as a means of attaining a range of domestic goals."[59] Similar to the presidential ranking above, Logsdon's analysis places Kennedy at the high end and Carter at the low, and distributes the others at various points throughout the middle. Kennedy, he notes, "was convinced of the link between space leadership and core US interests, and that conviction led to his decision to use his public office to mobilize the national will and resources that produced Project Apollo."[60] Carter, on the other hand, did not embrace the concept that space leadership was important and thus, was not supportive of a strong program. Eisenhower did not really believe that being the leader was important, but while Johnson may have, "he found himself unable to allocate to the space program the resources required to sustain that leadership once America reached the Moon."[61] Reagan, too, may have had a desire for US leadership in space, but he did not make the space program a top priority of his administration. For Nixon leadership in space was important, but it was leadership measured in international cooperation rather than in US superiority. Clinton saw value in space in forging a post-Cold War alliance with Russia. This was symbolized by the International Space Station (ISS) and Russia's inclusion into that program.

Limits of Presidential Interest

While interesting and informative, this presidential interest inventory and resulting judgment of success in the arena of space politics is much too

simplistic a perspective. History and subsequent in-depth analyses reveal that interest alone cannot account for the success or failure of space policy. A second factor that attempts to account for the lack of a coherent space policy revolves around limitations inherent in presidential interest.

To demonstrate the limits of interest, one space policy scholar, James Vedda, explored three major space projects involving presidential initiative: the Space Shuttle, the space station, and SEI. He notes that Nixon was not a space enthusiast and yet he did establish a new path for the space program by approving the Space Shuttle. In contrast, Reagan was a self-proclaimed space enthusiast, but he was not able to deliver much on the space station, despite giving a Kennedy-like speech filled with Apollo-like goals. Bush (89), too, was unable to make much headway, and he expressed a great deal of interest in returning to the Moon and sending a human expedition to Mars.[62]

Other space policy scholars, among them Roger Handberg and Joan Johnson-Freese, also agree that an interest-based focus is problematic and that it has, in all likelihood, severely hampered efforts to place the civilian space program on more stable footing.[63] But they clearly believe that the President is important in moving the space program forward: "Sustaining this presidential presence is essential for fostering productive activities in space."[64] Kennedy, they point out, was involved. He committed the US to the Apollo program and did whatever he could to make sure that fiscal and political resources were committed. Nixon, on the other hand, was not: "Once the President announced the [Space Shuttle] program, the designing was left to others to complete, from the congressional staff to budget officers. Lacking strong presidential support, NASA was forced to acquiesce to these external demands."[65] They find evidence of similar occurrences with Reagan and Bush (89), which lead them to conclude that "the real failure of the Presidents has been in not providing effective direction and discipline to those charged with formulating and implementing space policy."[66] Handberg and Johnson-Freese believe that space activities will not succeed until the President is once again directly involved in the process of policy formulation. Clearly, the continuing budget problems and cost overruns with ISS has been a factor that has led to a reassertion of presidential, and even congressional, direction over the formulation and implementation of space policy.

Roger D. Launius and Howard E. McCurdy also address the limits of presidential leadership. They note that "rather than accommodate themselves to the new policy formulation process, space supporters [have] placed the blame on the personality of the President and his unwillingness to step up to the kind of greatness that they believed Kennedy had exhibited."[67] In their view, the result was nearly forty years of trying to convince the President to take up the cause of space, a tactic that began to change only after the failure of the Space Station Freedom program and SEI during Bush's (89)

Administration. With the help of essays by several presidential scholars, Launius and McCurdy reveal how, in reality, space policy takes place at the intersection of the President, the Congress, and the bureaucracy. By the end of their text, there is no doubt that Kennedy and his Apollo decision were the exception to space policy, not the rule. The key point is that presidential leadership as the determinant factor in space policy formulation and implementation is in fact a myth.

Lack of a Coherent Vision

A third explanation for understanding the difficulty Presidents have had in forging space policy revolves around what Vedda calls "the inability to account for the intangible benefits of space exploration and development."[68] Presidents, in other words, have not adequately detailed the benefits of space. In *Space and the American Imagination,* McCurdy uses the example of American aviation to demonstrate this shortcoming in the US Space program. Aviation, he notes, "emerged from its barnstorming era to become one of the dominant technologies of the twentieth century. It did not fulfill the euphoric expectations of aviation pioneers, but it transformed society in significant ways."[69] This has not happened with the space program. No such alternative visions capable of sustaining space exploration have been formulated. McCurdy notes that "Advocates still embrace the original vision of adventure, mystery, and exploration. They continue to dream of expeditions to nearby planets and the discovery of habitable worlds."[70] McCurdy's conclusion, though not directly related to Presidents, is quite appropriate: if new visions can be forged, or if old visions can be restated in more appealing ways, then perhaps the space program can thrive.

Taking McCurdy's conclusion one step further it becomes apparent that if the space program is to thrive as it once did, then those who talk about the space program must be able to create a unified vision of space exploration and space use. A vision of space exploration without space use is as incomplete as one with space use without space exploration. Linda Krug contends that as of yet, no President has been able to overcome the fundamental contradiction between space exploration and space use in order to forge an appropriate vision of space exploration.[71]

This conclusion is based on an analysis of the images Presidents have used to talk about the space program. Krug reveals that Kennedy used the space program as a way to preserve national prestige and freedom, while Johnson turned it into a vehicle for achieving peace on Earth. Ford made space a tool for overcoming the shame of Watergate, while Carter used it as a

way to think about the concerns on Earth. Reagan capitalized on space as a means of economic and spiritual growth. Only Eisenhower, Nixon, and Bush (89) made a commitment to a pragmatic space program (i.e., a program based on the benefits that space in-and-of-itself could bring), and only Eisenhower and Bush envisioned long-range programs. Krug concludes that to date Presidents have been unable to merge space exploration and space use together to fashion their space policies. This merger cannot happen until a commitment is made to a space program as a space program, not as a means to some other social or political ends. Even President Kennedy, to illustrate this point, who had been credited with being a space visionary, supported a space policy for a Moon landing for political ends related to the Cold War and not because he had strong views on the long-term importance of space exploration.[72] Nothing short of a total vision, one merging exploration with use, will change the current direction of the space program.

Primary Versus Ancillary Policy

The fourth line of thinking regarding the limits on presidential space policy-making focuses on the shift from primary policy to ancillary policy. Civilian space policy now ranks in a lower tier of presidential concern, meaning that civilian space policy, "even when the President is personally interested, remains a marginal activity."[73] Civilian space efforts have, in other words, become "decoupled from US national interests."[74]

The distinction between primary and ancillary is substantial. Primary policy "establishes long-term goals and sets in motion organized efforts to achieve them. These include big ticket items that enjoy high agenda status–that is, they dominate public attention, public funds, and deliberation of public officials."[75] Ancillary policy does not set out to solve an identified national problem, and is characterized by incremental politics and institutional conflict.

In the 1960s, space policy was primary policy: "President Kennedy announced America's goal to land a man on the Moon by the end of the decade. That mission, framed as part of a race between the United States and the Soviet Union, gave the nascent space program a clear direction and purpose. It was a policy of innovation, instituted where nothing of a similar magnitude had existed before."[76] Over the ensuing years and continuing up to the present time, space policy slipped in stature and prestige. The start of its fall probably began with Johnson. President Johnson's only priority was landing a man on the Moon by the end of the decade. "Beyond that, he resisted significant commitments to post-Apollo planning that would cost billions of dollars and engage the country's prestige and energy."[77]

Simultaneously, the space program began its descent from a position of national priority due to growing economic problems, the decreasing values of space spectaculars as symbolic of national prestige, and the diminishing interest in space after the 1968 circumlunar flight and the 1969 Moon landing. Albeit Nixon did help to put the space program back on more solid footing, his frugality in government spending, followed by Carter's frugality, led to "a deceleration of the rate of space exploration in the 1970s, an emphasis on scientific return, and a commitment to obtaining the most efficient space effort for the least expenditure of funds."[78]

By the time Reagan took office in 1981, US space policy had become ancillary; decisions about the space program were made on a incremental basis; space policy was premised on "what can we afford" and "how can we sell it"; and conflicts between policy groups involved in space policy, including the Office of Management and Budget, the Office of Science and Technology Policy, the National Security Council, the President's Cabinet, and NASA itself, were intensifying. As a result, as much as they tried and is evidenced by their exploratory space rhetoric, neither Reagan nor Bush (89) were able to move the space exploration program forward (i.e., human spaceflight beyond low Earth orbit). Space as ancillary politics and policy prevented any such movement from occurring.

Decline of the Power Presidency

Essentially, there are three approaches to presidential policy-making in the literature that address the idea of the power Presidency and its decline over time. In addition to the power Presidency, this includes the persuasive and the strategically configured Presidency. The power Presidency is one of transformational leadership. In this case, the President is seen as an independent variable in the policy process, one that is a prime mover of public policy. This can occur in the realm of domestic and foreign policies. Relevant examples include the presidential space policies that supported Apollo, Space Shuttle, and ISS.

In the post-Apollo era, the Presidency has lost power relative to Congress on space issues. The power Presidency, the view advanced by power elite theorists that portray the President as easily able to quell opposing influences, is no longer supported by empirical evidence. Launius and McCurdy refer to a similar phenomenon, the imperial Presidency, and suggest that while it may have prevailed until the 1970s, it has now given way to a different understanding of the Presidency, one called the persuasive Presidency. It suggests that the President, while having a symbolic advantage

as leader of the nation, operates in an environment of shifting power alignments and faces major limitations on his influences due to the actions of Congress, the bureaucracy, and the popular will as expressed through advocacy groups.[79]

The persuasive Presidency is one of transactional leadership. Here the President is a dependent variable in the policy processes. The President is acted upon by a number of political players, such as Congress and advocacy coalitions, and as a result the President tries to satisfy the interests of these players. Eisenhower was persuaded upon by the environment of political forces to take action to create NASA in light of Sputnik. Nixon, Ford, Carter, and more recently Clinton and Bush (01) all were acted upon to downsize and scale back space expenditures, particularly in human spaceflight, due to domestic political forces and circumstances.

Lastly, the strategically configured notion is one where presidential space policy-making is constrained by the larger institutional context of the government. W. D. Kay notes that the very structure of the US government can be counter productive to the establishment of long-term space exploration policies.[80] The democratic environment works to exacerbate the very features of the space program, such as cost and complexity, which are difficult to deal with in the policy process. It necessitates that the President in formulating space policy must reach a consensus with other political actors and the space bureaucracy. This serves to further fragment space policy and makes the emergence of a coherent policy even more elusive. A case in point is the way in which Johnson was configured by the failures in the Vietnam War and his "Great Society" domestic agenda. This configuration prevented Johnson from advocating and supporting post-Apollo plans.

PRESIDENT AS A POLITICAL PLAYER

The five factors discussed in this chapter indicate that the President is just one political player in the formulation of space policy. This is exemplified by the evolution of policy with regard to Landsat.[81] There were two important policy issues. One issue dealt with whether Landsat is an experimental or operational system, and the other issue concerned Landsat commercialization. In this case, both the President (including the executive branch of government and the space bureaucracy) and Congress co-determined Landsat policy.

The experimental versus operational Landsat policy debate related to the program's administration through either NASA or the National Oceanic and Atmospheric Administration (NOAA). NASA sought to maintain the experimental nature of Landsat to allow for further technological

development, while NOAA, which is in the Department of Commerce, favored a policy that would make Landsat operational allowing for greater use both in the public and private sectors. In 1978, a Presidential Decision asked that NASA and the Department of Commerce find ways to encourage private industry participation in civilian remote sensing including Landsat and weather satellites. With the successful operations of Landsats 1 through 3, the 1978 Decision was followed by a 1979 Presidential Decision that moved Landsat operations from NASA to NOAA, and recommended a transition of operations to the private sector. As administration officials at the time viewed it, "NOAA was much better suited to managing operational systems, leaving NASA free to pursue research and development of more advanced Earth observations..."[82] They believed that under NOAA's management the user base for data would eventually mature to the point that private firms could fund, develop, and operate their own remote sensing systems for government and private markets.

The 1979 Presidential Decision precipitated the commercial policy debate. Congress followed this lead by passing Public Law 97-324 in 1981 that required the Department of Commerce to contract three independent studies to explore the transfer of Landsat to the commercial sector. The three studies all concluded that no option exists for commercial operation of Landsat without substantial government subsidies. Despite these conclusions, President Reagan accelerated the pace of Landsat commercialization and called for an immediate end to government funding of the program. Reagan's proposal called not only for the commercialization of Landsat, but also for privatizing meteorological satellites.

This position contradicted congressional policy preferences in that meteorological satellite data was viewed by Congress as a public good. Because the issue of meteorological satellites was impeding progress on the transfer of Landsat to the commercial sector, Congress passed a resolution in 1983 that effectively excluded meteorological satellites from privatization. This led Congress to legislate two public laws; Public Law 98-166 prohibited the government from privatizing operational weather satellites; and Public Law 98-365, "Land Remote Sensing Commercialization Act of 1984," established a process for commercializing Landsat that involved government subsidies. Even though the President partially got what he wanted (i.e., commercialization of Landsat), Congress used its law-making powers to make sure that meteorological satellites were not included in commercialization schemes, and that Landsat commercialization was phased-in with subsidies and not immediate as advocated by Reagan.

Phased commercialization of Landsat began with the establishment of the Earth Observation Satellite Company (Eosat) in 1985. The Department of

Commerce envisioned that with government subsidies Eosat would operate and market the data for Landsats 4 and 5, and develop, build, and operate Landsats 6 and 7. Both the Reagan Administration and Congress anticipated that revenue from Landsat data sales would allow Eosat to support private ownership and operation of the Landsat system.

This did not take place due to a number of reasons. First, Eosat was unable to generate enough revenue from data sales to assume operations of Landsat and to make privatization viable.[83] Second, policy disagreements between Reagan and Congress over the amount of subsidies, and the phased commercialization process delayed a decision to fund the Landsat system until 1987. Third, NOAA announced in 1989 that its funds for Landsat operations were spent and directed Eosat to turn-off the satellites. Congress and also Landsat data users opposed NOAA's action. This opposition was translated into presidential support for continued Landsat operations and additional congressional appropriations for operations in 1990.

Due to these problems associated with Landsat commercialization, President Bush (89), through a national space policy directive of 1992, advocated a strategy for assuming NASA and DOD co-management of Landsat. Congress followed this lead and passed the "Land Remote Sensing Policy Act of 1992" that effectively repealed the 1984 Act. As a result, management and operation of Landsat was returned to governmental control. Today, Landsat is co-managed and operated by NASA, NOAA, and the US Geological Survey (USGS).

The Landsat case shows that the President and Congress co-determine space policy. Space is in the policy domain of the President, but Congress will get involved when its policy preferences diverge from those of the President. Further, once Congress acts an issue it has institutional and political reasons for staying involved to oversee the program and make policy changes such as the 1992 Act that brought an end to the phased commercialization of Landsat. Beginning in the late 1980s, this trend of congressional involvement, and even divergence from presidential space policy preferences, has become more the norm than the exception.

Figure 4.1 illustrates this trend through an examination of the President's budget request for NASA in relation to congressional appropriations for NASA. Albeit in most cases presidential policy preferences are matched with congressional ones as it concerns NASA's budgets, there are a number of times where there is a discrepancy between the two political actors. This discrepancy, which began to take hold following the 1986 Space Shuttle Challenger accident, indicates a greater degree of congressional involvement in formulating space policy.

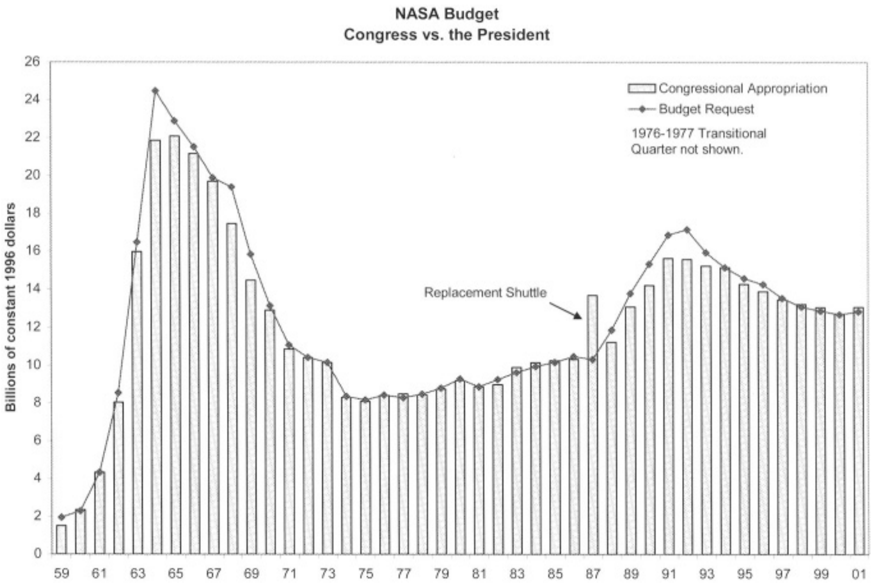

Figure 4.1. NASA's Budget: Congress and the President.
Source: compiled by Eligar Sadeh and Trent Benisch.

CONCLUSIONS

There are more factors, such as partisanship, changing ideology, and pork-barrel politics,[84] which have played a role in the failure of Presidents to establish a long-term space exploration program and the corresponding space policy. These other factors are addressed elsewhere in this book primarily in the next chapter on Congress and Space Policy. The five factors discussed in this chapter– level of presidential interest, limits to presidential interest, lack of a coherent vision, shift from primary to ancillary policy, and the decline of the power Presidency– track the shift away from a conception of the Presidency as powerful and towards one as rhetorical or persuasive.

With the help of such texts as *Spaceflight and the Myth of Presidential Leadership,* essays like "Evolution of the Executive Branch Space Policy Making" and "The Myth of Presidential Attention to Space Policy," and the Landsat case study, those interested in space have begun to come to terms with the limitations inherent in a perspective, which assumes presidential superiority over space politics and policy. Presidents are not solitary actors; the President has an advantage as the symbolic leader and presidential rhetoric influences policy outcomes, but when it comes to space policy-making they are just one of the political players.

5
CONGRESS AND SPACE POLICY

Joan Johnson-Freese*

> "If the taxpayers believe that the space program is becoming a cosmic carnival ride, then we face the very real prospect that they may withdraw their public support."
>
> *United States Senator John Glenn*

INTRODUCTION

The astronaut-turned-Senator making that statement in 1986 returned to space in 1998 on the Space Shuttle. Senator John Glenn had publicly campaigned for months prior to his 1998 Shuttle mission for permission to make another trip to orbit since his one-and-only prior flight in 1962 as a Mercury astronaut. The reason given by NASA for Glenn's selection was so that scientific research on aging (Glenn being 76 at the time of his second spaceflight) could be conducted in space. To some people, that reasoning sounded contrived and offered primarily as a pretense to deflect potential criticism over Senator Glenn wanting one more ride on the "cosmic carnival" and NASA's willingness to accommodate.

Fortunately for NASA, it matters little what the public thought of its motivation for giving Senator Glenn one of the coveted mission assignments-assignments for which professional astronauts may wait years. There are those who saw Glenn's flight as "the ego express" rejecting the plausibility that much serious medical research was conducted over approximately one week with one data point. Some insiders suggest that it was NASA deputy administrators, who also happened to be Marines, as was Senator Glenn, who pushed through his assignment. Others speculate that the White House urged the assignment as a reward for a loyal political ally. On the other hand, many people are supportive and do not need much of a reason. They feel that since the United States (US) is spending upward of $500 million on each Shuttle

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mission anyway, why not send an already established national hero along, if only for the public relations returns and potentially to pave the way for other civilians.[1] The latter is the most legitimate rationale.

The fact of the matter is that during President Clinton's State of the Union Address in January 1998, the House Chamber rocked with applause, congressional members cheering one of their own, when the President referenced Glenn's return to orbit. NASA is well aware who appropriates their funds. Indeed, Glenn is not the first member of Congress to fly in space. Following the 1984 elections, NASA announced it was going to limit the number of congressional participants on the Shuttle to four. Those who would be considered were the two Republican chairmen of the Senate subcommittee that have jurisdiction over the space program, and their counterparts in the House of Representatives– the two Democratic chairmen of the House subcommittees.[2] Subsequently, Senator Jake Garner (Republican, Utah) flew in 1985 and Congressman Bill Nelson (Democrat, Florida) flew in 1986. Questions were raised then too about whether some real purpose was served related to their positions in Congress or whether it was the ultimate carnival ride. From the perspective that customers must be accommodated to garner political support, NASA seems to have done well in the earlier cases and with Senator Glenn's return to space.

Space has rarely been a political priority for Congress, though it certainly has represented a policy interest. The 1998 situation involving Senator Glenn serves as an illustrative example in a broader examination of the relationship between Congress and space policy. It demonstrates that the relationship is characterized primarily by inconsistency, political personalities, and secondary motivations and rationales, rather than high-priority decision-making. In some respects, that makes space no different than other areas served by public policy. However, there are important and specific differences unique to congressional space policy. The objective of this chapter is to explain on what basis Congress has established and maintained interests in space, and to understand what one might expect in future space policies.

SPACE AND CONGRESSIONAL OVERSIGHT

The literature examining the relationship between Congress and space policy falls into one of three basic categories: information sources, case studies, and general analysis. Because the jurisdictional lines concerning space and the committee system under which Congress operates has changed several times over past years, the first type of literature can become dated. Much of the informational literature dealing with the relationship between

Congress and space policy begins by examining the premise of the congressional oversight role and then focuses on the mechanics of the political and policy processes at the time.[3] Although the mechanics of the oversight process have gone through modifications, the premise of oversight has remained basically consistent.

Congress and space are linked primarily through congressional budgeting power; congressional authorization committees approve substantive programs submitted in the President's budget through a sponsoring agency and then the subcommittees of the House and Senate and appropriations committees actually fund those programs according to a variety of factors. This funding requirement for both programmatic authorization and appropriation holds true within any public policy field, be it education, defense, welfare, or space. However, changes in committee mechanics, such as the reforms in the 1970s that fragmented and multiplied the number of committees having an interest in space, have had substantive impact regarding space specifically. It is both the fragmentation at the committee level and the secondary economic relevance of space at the state and district level that differentiates space from many other public policy areas.[4]

In broad terms of fragmentation, for example, military space programs are authorized by a different set of committees than are civil space programs. This complicates attempts at encouraging space policy cooperation and consolidation. Further, space, in simple terms of both constituent and interest group support, rarely generates enough momentum to force it as a high-priority congressional issue. Outside of certain geographic areas not enough voters have a direct financial stake in space activities to make it a voting issue for them. Congress, therefore, has the luxury of interceding or not interceding, knowing that few people will know or care one way or the other.

Comprised of 535 members (100 Senators and 435 Representatives), the majority of congressional work is done at the committee and subcommittee level where perspectives are largely parochial. Congress as a whole provides guidance to the committees, especially through the budget resolutions. But ultimately, it is the committees and their components that structure the outcomes. The House and Senate normally work on bills and resolutions submitted by committees. This is especially true for space policy, where interested members are few in number, and usually serve on one of the relevant committees, and most outside the committee have comparatively little concern.

NASA's appropriations are established by the Veteran's Affairs, Housing and Urban Development (VA-HUD) and Independent Agencies Appropriations Subcommittee in the House and Senate. Competition for this

discretionary part of the total federal budget, from which is funded everything from education, to veterans, to roads, and to the civil space program, is intense. The VA-HUD Independent Agencies Subcommittee, with rare exception, develops a single bill that encompasses proposed appropriations for NASA as well as the other agencies in its purview, including the Department of Veterans Affairs, Department of Housing and Urban Development, Environmental Protection Agency, National Science Foundation, Federal Emergency Management Agency, and some dozen smaller agencies. Looking at that list, it is useful to think in terms of numbers of voters in each category directly benefiting from federal expenditures. When viewed in those terms, space does quite well in this discretionary budget battle considering its relatively small constituency.

Military space programs are in a similar quandary. Certainly the defense contractors form a powerful congressional lobby. But considering the primary focus of the larger companies involved (e.g., Lockheed-Martin and Boeing), most if not all the companies garner the bulk of their federal funding from more traditional areas of the military, like airplanes and weapons, rather than space. Therefore, the aerospace industry will focus the bulk of their efforts there rather than on space.

In the American context, support for specific projects or agencies becomes an annual affair. As priorities on the policy agenda wax and wane, so do budget allocations. The International Space Station (ISS), for example, has annually been subjected to efforts directed at policy change with varying intensity to terminate the program or stretch it out to the brink of failure. In 1993, the House of Representatives rejected an amendment to cancel the entire program by only one vote. In 1998 (the year that the first elements of ISS were launched into orbit) and in 2001 (after ISS was inhabited by its first Astronaut crews) the program was questioned, primarily in conjunction with problems associated with Russian cooperation and NASA mismanagement leading to cost overruns on the station's congressional imposed budget caps.

The point is that all civil space programs usually run this political gauntlet regardless of their merits. Congress has shown willingness over time, as the space program has matured, to change its mind repeatedly as other issues are placed on the public policy agenda. The result is a space program driven by high anxiety about congressional reactions leading to concealment as a strategy for NASA to avoid congressional interference in policy formulation and implementation. Unfortunately, when the concealment is exposed, the situation becomes worse because no one in Congress then believes the affected agency and the tendency for congressional oversight and micromanagement is strengthened.[5]

The overall lack of interest in civil space matters is countered by congressional reluctance to interfere with the defense budget. As long as

certain key members of Congress are satisfied, the defense space area has been relatively immune to congressional involvement. Rather, the President normally makes the defining decisions; congressional critics have an uphill battle and often require dissidence within the Department of Defense (DOD) to be successful.

The Strategic Defense Initiative (SDI), an extension of the long running anti-ballistic missile (ABM) debate, represents an excellent example of this process in action. Congressional resistance grew over time as the technical issues remained substantial with no guarantees of success. Division within defense circles helped foster SDI's eventual demise. Collapsing defense budgets put further nails in its coffin because each military service had its institutional priorities, SDI not being necessarily a high priority.

First under the Bush (89) Administration in the early 1990s, and more pronouncedly under Clinton, the remnants of SDI, in the form of ABM efforts, became a bargaining chip, nicely illustrating how administration-in-office attitudes influence policy interpretation and how personal interactions between the President and members of Congress can be critical.

> Reversing...Republican policy, the Administration has informed the Senate it will adhere to the traditional interpretation of the ABM Treaty. The Treaty, which the Reagan and Bush Administrations unsuccessfully sought to circumvent on a legal basis, bans ABM activity except research and confines deployment to a single site of 100 fixed-point missiles. The return to the original interpretation gives the White House a concrete policy justification for sharply reducing ABM spending down the road. The move may also help President Clinton repair his sullen relations over the gay issue in the military with Senate Armed Services Committee Chief Sam Nunn, the leading advocate of the original interpretation. In their quest for a space-based ABM defense under SDI, Reagan and Bush pressed unilaterally for a broad interpretation that would have allowed both testing and deployment of mobile and space-based exotic weapons technology– "exotic" referring to technologies not current in 1972. Nunn argued that a unilateral interpretation raised profound Constitutional questions. He also argued it was illegal to test or deploy SDI kinetic kill vehicles under either interpretation.[6]

Efforts at reviving SDI-type initiatives, begun with the Republican congressional majority elected in 1992, have been scaled down to a focus upon theater level ballistic missile defense systems, which President Bush

(89) initiated and Presidents Clinton and Bush (01) supported with a technology development effort designated the National Missile Defense (NMD) and Ballistic Missile Defense (BMD) respectively. DOD enthusiasm for SDI type initiatives has been constrained in part because other issues related to military readiness are deemed greater priorities. Even though the military service chiefs support service modernization efforts, they (the Commander-in-Chief of the Unified Command) argue for military operations. In other words, the preference to buy more planes, ships, and tanks is greater than the development and acquisition of space hardware.

Part of the past pattern of congressional deference to the DOD has occurred because a significant portion of the DOD space effort occurs in the "black." That means that probably ninety percent of what Congress accepts are the committee decisions. In effect, these decisions are based on their faith in committee leadership. Essentially, this situation means that a mutually reinforcing power configuration arises, which minimizes radical or drastic policy change. Continuity and, to a large extent, inertia characterize the military space area. Occasionally, the general congressional population takes offense at its smaller-number, committee-member allowances. This can be seen in the congressional surprise and outrage when the National Reconnaissance Office (NRO) was found to have sequestered sufficient funds to build a $300 million new headquarters without full congressional authorization. Furthermore, the NRO had accumulated in excess of $2 billion in carry-forward accounts. The Clinton Administration changed NRO's fiscal oversight and fired its leadership in response to congressional concern over the carry-forward accounts.[7]

Few congressional members are "self-educated" about space, usually because of low political relevance to their district and a certain hesitancy and intimidation about being too involved due to the space program's high-technology nature.

> The United States Senate is not a cross-section of America. The framers of the Constitution never anticipated that it would be. So today [1988], sixty-five of our 100 Senators were trained as lawyers... A dozen Senators have a business background. There are four farmers, two bankers, plus a variety of other occupations, from a former social worker to a former pro basketball star...with all that talent, one broad discipline is missing...not a single member of today's United States Senate is a scientist. The closest we come is one civil engineer (Senator Evans of Washington) and one astronaut (Senator Glenn of Ohio).[8]

This does not imply, however, that Congress is lacking for information on the space policies and programs that it considers.

Information Sources

Congressional members are often overwhelmed with information. To cite an instance, in the mid-1980s a group called the International Hypersonic Research Institute (IHRI) was advocating the development of the National Aerospace Plane (NASP). IHRI wanted to send fourteen-minute videotapes to each member of Congress to inform them of the technology and benefits associated with the program. Use of videos, which could be viewed at their convenience, it was thought, would be far more effective than trying to speak with members personally. Several staffers suggested that IHRI was wasting its money. Anything more than a six-seven minute audio tape, which the member could listen to in their car, they were told, demanded more time than the members could likely afford. On highly technical matters such as space, one can rapidly begin to understand the difficulty.

According to a former Ranking Republican on the House Appropriations Committee and on its VA-HUD-Independent Agency Subcommittee, what the space program needs is "solid, honest, and long-range scientific knowledge."[9] The primary source of information for both the President and Congress are the Office of Science and Technology Policy (OSTP), National Science Foundation (NSF), Office of Technology Assessment (OTA), National Research Council (NRC), and advisory groups with federal agencies such as the Space Studies Board of the National Academy of Sciences (NAS). OSTP and the advisory groups, however, are too politicized and the OTA was disbanded in 1995. That leaves the NSF, NRC, NAS, and the multitude of advocacy coalitions that barrage Congress with their parochial view of issues.[10] Because of the time demands already cited, it may simply be that the view with the most persistent advocate or last view heard becomes the dominant policy on the congressional agenda.

Obviously, much of the substantive work of Congress must be delegated. Individual and committee staffs have taken on that task. The committees that deal with space have gained the reputation of including some of the top technical people in government. Concomitantly, congressional staff have become known as a cadre of individuals who many feel have gone beyond their intended role and become a powerful political force to deal with in-and-of-themselves. The almost five-fold increase in congressional staff since the 1960s has only worsened the problem, as one of the primary responsibilities of a staffer is to generate programs or cripple those in disfavor.

The influence of congressional staff should be neither overlooked nor underestimated. Congressional staffers hostile to the development of the then McDonnell Douglas DC-X (Delta Clipper) reusable launch vehicle (RLV), for example, went so far as to anonymously distribute misinformation about the program.[11] This played a role in the eventual decision taken by NASA's then RLV initiative to support the proposal put forward by Lockheed-Martin, which was designated the Venture Star, rather than to select Delta Clipper. Ironically, the Venture Star program was terminated in 2001 given technical failures in prototype technology development. In the wake of this policy failure, NASA reinstated a new RLV Space Launch Initiative to find a Space Shuttle replacement for the future.

Case Studies

Written information and documentation for use by Congress and others is becoming increasingly available. The NASA History Office has provided as of 2001 five volumes of information of a different type, previously available only on a piecemeal basis. These are documents from the history of the US civil space program (though that description is modest as the documents are actually far more encompassing and analytic) that already have proved invaluable to researchers and historians.[12] These works provide important information from which historical case studies and general analyses can be drawn.

Academically, case studies provide snapshots of space activity, which often include to some lesser or greater degree assessments of congressional involvement. Examinations of the International Solar Polar Mission (ISPM),[13] Space Exploration Initiative (SEI),[14] and ISS[15] have been helpful in understanding the interaction between Congress, NASA, and the President.

General Analysis

The general analysis category of literature has been perhaps the most fruitful, though also the most nebulous, in examining the role of Congress in space policy. These are "big picture" books among which Walter A. McDougall's book *...the Heavens and the Earth: A Political History of the Space Age*[16] is preeminent. As a political history of the beginnings of the space age, it describes the long tentacles, which reach through recent history, in sometimes very personal ways, among Congress and the government concerning space. More recently, *Can Democracies Fly in Space*[17] and *Space, the Dormant Frontier* examine the current space policy milieu and

consequent issues. The former book focuses primarily on civil space while the latter encompasses both civil and military. Both of these books find that the historical roots of the space program, described by McDougall, are now a legacy influencing its very growth and development. The depth of the ties between the past and present are such that understanding the role of Congress in space policy today requires a look into the past history.

FOREIGN POLICY LEGACY

In the late 1940s and early to mid-1950s, the US national security community was more preoccupied with developing a surveillance capability of the Soviet Union than it was in developing a missile or a rocket, differentiated primarily by its destination and payload. At that time, the destination would have been sub-orbital and the payload would have been a nuclear warhead. The US had bombers, the B-47s and B-52s of the Strategic Air Command (SAC). Most of the space activity in the US was through the military and missile development was not highly prioritized largely due to the Air Force culture being driven by pilots and SAC. By the time Sputnik was launched in 1957, however, the US was working on several launch vehicles, including the Army's rocket that Wernher von Braun had developed at the Redstone arsenal (this became the Marshall Spaceflight Center when NASA was established in 1958), which would eventually be used to launch the first US satellite, Explorer, in 1958.

That fact was not enough, though, to ebb the flow of congressional criticism toward the Eisenhower Administration that emanated from Sputnik and subsequent claims of a "missile gap" between the US and the Soviet Union. It is here, in the very early days of the US space program, that space became inextricably relegated as the means to realize goals linked to other public policy areas, usually foreign policy. In other words, space would be viewed as a means to achieve some other policy goal, rather than having intrinsic goals of its own. Further, the first space activity that the American public was made aware of on a large-scale basis was one involving a foreign nation gaining a potential military advantage over the US through a demonstration of its space capabilities. It was not through an effort to explore the unknown, through a scientific expedition, or even a commercial venture. Space and space technologies were first identified as weapons of the Cold War.

Not surprisingly, on such high profile issues as Sputnik and the missile gap, partisan politics became a factor in the circuitous development of space. The Republicans, it was claimed, had gotten the US into this untenable

"missile gap" situation by not spending enough on space, so the Democrats (led by Senate Majority Leader Lyndon B. Johnson) were willing to guide the way to correct things. The military continued its work on launch and surveillance at an increasingly high-price but with a low profile. NASA was conceived[18] in 1958 and the Apollo program eventually birthed with the highly focused goal of sending and returning a man to the Moon by the end of the 1960s to demonstrate US superiority in space by beating the Soviets. Even that program, a weapon of the Cold War, had to spread its money and jobs throughout the fifty states of the US in order to garner sufficient congressional support to carry it through to completion.[19]

Then, after Apollo achieved the goal of beating the Soviets to the Moon, it would be the Republicans who would step in to point out how the Democrats were wasting money by spending further funds on space. Once the foreign policy goal had been achieved, the raison d'être for the space program and NASA evaporated. Later, with the ending of the Cold War, in 1991-1992, a similar fate befell the military space program. No longer charged with "watching" the Soviet Union and being prepared to respond to any challenge in kind, Congress suddenly wondered why some of the monies that had gone toward those goals could not be included in the highly acclaimed, though elusive post Cold War "peace dividend."

Whereas partisan politics was critical in the early years of the space program, it has become less so in the post-Apollo era. With a few notable exceptions, space has become largely a non-partisan issue.[20] That former NASA Administrator Daniel Goldin was appointed by President Bush (89), survived the transition to the Clinton Administration, and only resigned in November of 2001 speaks not only to Goldin's political and managerial acumen, but also to the secondary political importance attributed to the space enterprise. Politicians covet opportunities to reward loyal followers through political appointments and to forego such an opportunity can be interpreted both as a nod for the status quo and at least partial presidential indifference.[21]

The anomalous circumstances of this developmental period for space activity have left a legacy of unfortunate precedents and predilections, which remain in place today. Clearly, the high-risk, high-tech nature of space technology is such that without government support it is unlikely that much in space would have occurred, let alone the extraordinary achievements of landing a man on the Moon. Space, however, is neither exclusively a service (such as health care, education, or transportation) nor a place (like "foreign" or "domestic"), nor a system, which requires regulation (through such organizations as the Environmental Protection Agency, Securities and Exchange Commission, or Federal Aviation Authority), nor a national security asset, but a hybrid combination of all of them. Whereas the US has experience dealing with each individually, there are few other policy

examples where all are involved. Analogies to space that can and have been used are the opening of the American West or the development of the airplane industry. In each case the government played a preeminent role initially, but then stepped out the way and let the private sector take over.

The degree of involvement of the US government in space, as funded by Congress, is still significant. Albeit the private sector is making headway, the primary customer is still the federal government with the exception of the telecommunications field. This gives the government body that makes the financial decisions (i.e., Congress) an important and sometimes determinative role. Some congressional members and staffers, especially those not directly involved with space issues, view NASA as an entitlement or jobs program for its employees and contractors. This view seems particularly influenced by the travails of ISS, which many see as the ultimate "White Elephant" program. ISS comes up all too often as a negative example of how things get done in government. As the program proceeds toward full operational status, questions are still being raised as to "why?" The answer often concerns the jobs created here on Earth:

> More than 5,000 people are employed by Boeing's space station program in the United States, with at least another 5,000 working for subcontractors, suppliers and NASA itself. This spreads to perhaps 30,000 more who benefit indirectly... Boeing has subcontractors all over the United States, including 49 in California alone.[22]

Not surprisingly, costs spiral when spent for maximum political, rather than technical or developmental effectiveness. Nevertheless, when public monies are being spent, everyone will want something in return. That means that like a cowboy with a gun, when Congress tells NASA to dance, NASA dances. Further, the dance Congress is looking for may frequently change, so the dancers need to pay close attention to the tune. All this is critical if NASA is to be successful in aligning its policies, plans, and budgets that are appropriated by Congress.

For example, in the 1980s, then NASA Administrator James Beggs, had what many felt was the audacity to suggest privatizing Space Shuttle operations. This idea was quashed in Congress, The reasons given by DOD and Congress included the need for government control of military missions carried out by the Space Shuttle and the issue of national pride in the space program.[23] The problem from Beggs' perspective though, was that the Shuttle was an expensive piece of symbolic pride to maintain and operate. In 1994, however, Congress not only revitalized the idea of privatizing the Shuttle,

they demanded it. Evidently, prestige is not so valuable a commodity in leaner economic times. The United Space Alliance (USA), a consortium of private companies selected in 1995, runs Shuttle operations for NASA.

CONGRESSIONAL DECISION-MAKING FACTORS

Congress, in parallel to its vast responsibilities (far more than any other branch of government if one goes by space afforded to it in the US Constitution) has an equally large number of interests to which it must be responsive. Subsequently, its members are often torn in their obligations. Though the actions of the institution and those who serve as members may come across as fickle, policy actions of members are often pragmatic and are taken only after significant consideration.

The degree of importance that the many roles and obligations impose on congressional members is such that they have been the focus of considerable study, under the title of role theory, role conflict, or role analysis.[24] Hannah Pitkin's 1967 book, *The Concept of Representation*[25] began the theoretical examination of the topic, which continues today as new influences on Congress come into play. Representatives simultaneously act as, among other things, champion of the home constituency, legislator for the national interest, loyal party member, substantive expert in multiple fields, and friend to assorted lobbyists. New members sometimes quickly feel that it was easier to have a black and white view of the world as a candidate than it is after election, when practical and altruistic worlds suddenly and quickly collide. "I never perceived that the measure of my effectiveness should be how deep I could get my finger in the federal till. How can you be true to your...faith if you're always after the pork barrel."[26]

Provider of Good Things to Voters Back Home

Congressional members were said usually to leave their position in one of two ways: the ballot box or a pine box. Concerning the first, members truly do serve at the pleasure of their constituents. For members of the House of Representatives, that pleasure is tested every two years, in the Senate it is every six years. That means that at least on the House side, members are constantly running for reelection. Constituent pleasure is usually reflected in some very specific indicators, especially the unemployment rate and the amount of federal money being spent in home districts.

What this means is that there are members whose space vote is based on the space-related facilities in their district (e.g., the various NASA centers, educational institutions, and aerospace contractors).[27] Kennedy Space Center

(KSC) in Florida, for example, is tightly wedded to the Space Shuttle program. Therefore, discussion of new, easier to operate launch systems brings chills to area politicians. Even though easier, cheaper access to space might well create jobs in KSC's surrounding area, at some point Shuttle workers would be forced to seek other employment, which politicians simply do not want to happen during their tenure. At the same time, NASA facilities have been forced to shrink to survive during the increasingly leaner years following the Apollo program.[28] Always careful to be politically correct, the words used to describe how this "shrinkage" is accomplished are interesting. People are not fired, positions are not cut; hiring freezes, restructuring, redeployment, and "outplacements" occur.[29] The House Member from the KSC district has had to deal with this as the Shuttle work force was restructured and partially privatized through the USA consortium.[30]

Just as members need to be responsive to their constituents, so NASA must be responsive to Congress. In 1994, NASA considered moving Shuttle-related jobs from California to KSC for cost reduction purposes. Congressional oversight had strongly mandated that NASA tighten its belt. Eventually though, the agency had to forget that particular cost-saving effort. Those California jobs were in the district of Democratic Congressman George Brown, then chairman of the House Science, Space and Technology Committee, and he pointedly asked NASA to reconsider. In fact, NASA "accepted" Brown's reasoning for keeping the California facility open and even decided that it would create "substantial savings" for operating the Shuttle.[31] In 1995, the question of those California Shuttle jobs returned to the table again because the Republicans were the majority in Congress, and their interests were different. California jobs remain important political considerations, but Republicans elsewhere have different agendas. In June of 1996, NASA ventured where it had not dared to go prior and announced that it was moving the inspections and maintenance work done in its California Palmdale facility to KSC for cost-savings. Representative Brown said he hoped NASA would make "no precipitous, penny-wise, and pound-foolish decisions."[32] With elections every two years, this is a story without an end.

Additional examples abound– the ability to keep Advanced Solid Rocket Motor (ASRM) in the NASA budget for multiple years against Agency wishes because it was in an influential representative's district; Senator John Glenn of Ohio got a Supercomputing Center in Ohio through the NASA budget; and the Air Force received additional Georgia-built C-130 transporters during Georgia Senator Sam Nunn's tenure on the Senate Armed Services Committee.[33] Although the C-130s are not "space" hardware and were received by the Air Force as budget add-ons rather than budget requests (i.e., the Air Force did not want or request additional C-130s), they are

indicative of the DOD's as well as NASA's need to please Congress. In late 1997, Senate Majority Leader Trent Lott of Mississippi successfully defended the Space Based Laser (SBL) Readiness Demonstrator program from President Clinton's Line Item Veto, which had deleted several other military space programs, such as Clementine II, the Army's Kinetic Energy Anti-Satellite System (KEASAT), and the military space plane. Not surprisingly, Mississippi, the Senator Lott's home state, stood to benefit considerably from these programs.

These examples are not different than ones concerning members being generally supportive of military base closures as a long-term cost saving measure for the military, as long as it is not in their district, or in favor of cutting farm subsidies, unless you are from some place like Iowa or North Dakota. This is not nefarious, nor unexpected, but simply pragmatic[34] and a factor to be recognized as one among many which contributes to the apparent schizophrenic behavior that drives space policy and space programs. Policies are fine as general statements of intent, but if the policy interferes with a local "pork-barrel" program, it likely will be overlooked or circumvented even if placed on the policy agenda. The final result for the space program is that policy, plans, and programs are often incongruous with each other, and moreover, incongruous with budgetary allocations forthcoming from congressional appropriations.

Place Filler

Constitutionally, the Executive Branch of government is primarily responsible for initiating policy, to which Congress then responds. Congress is institutionally incapable of primary policy in any field because of its size and deliberate incremental nature. The very nature of congressional politics lends itself to ancillary or incremental policy-making. As such, it is appropriate that Congress has not aggressively sought to charter new and revolutionary primary policies for space. On occasion, however, Congress has stepped in as the policy leader when the President has left a political vacuum.

To illustrate, President Ronald Reagan was particularly noted for his tendency to made grandiose statements about space with little political commitment behind them. The ISS program was announced in 1984, but was given little attention by the Administration beyond the original rhetoric, as the Strategic Defense Initiative (SDI) was clearly the flagship of the Administration's space efforts. The same "rhetorical support" pattern occurred with the National Aerospace Plane Program in 1986. Suffering from the benign neglect of the Administration, and post-Challenger managerial

paralysis within NASA, Congress took the lead in that period in greater political oversight and "micromanagement" of civil space programs.

That the Reagan Administration often seemed to make decisions by indecision, at least concerning space, is evidenced in the untenable length of time it took for the Administration to make up its mind about a replacement orbiter for Challenger. Subsequently, then Representative Bill Nelson of Florida introduced legislation to reinstate the National Space Council, which was originally instituted under President Johnson but had been dormant since the Nixon Administration, because the White House was so reluctant to take charge on space policy.[35]

As President Reagan lost interest in the ISS soon after its announcement in 1984, Congress stepped in and assumed policy control. NASA felt that Congress went overboard, eventually reaching the point of micromanaging the ISS program. Through legislation, NASA was directed to do certain things and not do others based many times on congressional staff judgments. This resulted in six major space station redesigns (and policy reformulation and reimplementation); President Clinton mandated the last major redesign in 1993 due to his policy of cooperation with the Russians on space station. Redesigns were reflective of language employed in House appropriation bills for NASA. The fiscal year 1991 budget stressed microgravity research and incorporated recommendations from the Advisory Committee on the Future of the US Space Program (i.e., the Augustine Commission) that focused on the space station as a laboratory for life sciences research.[36] Such micromanagement demoralized the already beleaguered, post-Challenger NASA– no technical judgment is immune to second-guessing by those not responsible for policy outcomes. The broader point is, when required to do so, Congress will take the initiative, though usually their role is more reactionary to presidential space policy.

Responsible Individuals

Because Congress must (and should) be responsible and accountable to their constituencies does not mean that they are not doing their best to look out for the welfare of the nation, through their stewardship of legislation and supporting appropriations. Indeed in this era of media scrutiny regarding nuance and minutiae of our public officials, why would anyone want to be in politics if they truly did not want to do a good job? The time demands imposed on members are staggering, the media relentless, and the stress considerable.

In the spring of 1980, a situation was brewing in Congress the result of which would later become almost notorious in the international space community. The NASA contribution to a joint NASA-European Space Agency (ESA) program, the International Solar Polar Mission (ISPM), was being debated. ISPM involved two spacecraft, one built by each Agency, traveling to opposite solar poles to enable unique photographic images to be produced. In a cost saving move in a period of draconian budget politics, the House Appropriations Committee decided to cancel funding for the US spacecraft much to the horror of the European partners who were already funding and building their spacecraft.

ESA mounted a strong diplomatic protest in reaction to the proposed cancellation, but to no avail. It was Representative Don Fuqua of Florida, then chairman of the House Science and Technology Committee, that opposed the cancellation. The program was spared from cancellation not after any discussion of program merit, diplomatic concerns, or the responsibility of the United States to uphold its commitments on joint international programs, but by citing "the rules." Cancellation of the program, it was pointed out, would constitute legislation in an appropriations bill, a violation of the House rules.[37] Unfortunately, the reprieve was short-lived and the eventual cancellation of the US spacecraft provided several negative lessons to actual and potential international partners concerning the risks of entering into commitments with the US as a partner.[38] Often times, congressional members will fight, and fight hard, for programs and policies that they feel strongly about, regardless of where it is being built, launched, or utilized. Their substantive and procedural knowledge in such cases can be invaluable.

Rational Quarterback

"Well, we're going to fix that." That statement was offered in 1992 by Representative John Murtha of Pennsylvania, then chairman of the DOD Subcommittee of the House Appropriations Committee, after questioning military officials about the management of national and military space programs, and receiving what he considered an unsatisfactory and convoluted answer. Congressman Murtha had asked a question about how space programs were coordinated in DOD. Specifically, the case that brought the coordination and management issues to the foreground concerned selecting a replacement for the Defense Support Program (DSP) missile early warning satellite architecture.

For ten years, US Space Command had been trying to define the requirements that would lead to an eventual follow-on for the aging DSP satellites, spending hundreds of millions of dollars on studies that never were

implemented. This seeming inability of DOD to determine its own "highest priority" requirements typified the problems Congress found with DOD space management and fueled subsequent frustration in Congress. Moreover, it led to Congressman Murtha stepping in and telling DOD to get their act together. This task has proven easier to direct than to accomplish.[39] Nevertheless, congressional oversight has on more than one occasion spurred individuals and organizations not otherwise inclined to at least give consideration to activities such as coordination, cost-effectiveness, and efficiency. There are times, however, that those being directed to clean up their house view this direction from Congress as hypocritical, feeling that they ought to start with themselves. Still, as long as Congress holds the big club in the appropriations committee, its direction cannot be disregarded.

Inconsonant Champions

Similar to the role of "place filler," congressional members sometimes will step forward to champion a worthy cause; but, because of the multitude of other issues and constituent concerns, they are usually unable to sustain their interest and momentum for very long. Planetary defense is an example of an area where Congress has shown the willingness to "champion a worthy cause," but has still been unable to push the issue over the threshold of interest on the policy agenda required to sustain activity without more time and effort than Congress is able to supply.

In 1980, scientist Luis Alvarez first proposed that it was the impact of an asteroid with Earth and the resultant global pall of dust that resulted in the mass extinction of many life forms on Earth, including the dinosaur. That proposition got the attention of not only the science community, but the public as well. The scientific interest triggered a series of workshops to examine the issue, many organized by NASA. Those workshops then led to recommendations being brought to the House Committee on Science, Space, and Technology. Subsequently, the House of Representatives, in its NASA Multiyear Authorization Act of 1990 included the following language:

> The Committee believes that it is imperative that the detection rate of Earth-orbit-crossing asteroids must be increased substantially, and that the means to destroy or alter the orbits of asteroids when they threaten collision should be defined and agreed upon internationally.
> The Committee therefore directs that NASA undertake two workshop studies. The first would define a program for dramatically increasing the detection rate of Earth-orbit-crossing asteroids; this study would

> address the costs, schedule, technology, and equipment required for precise definition of the orbits of such bodies. The second study would define systems and technologies to alter the orbits of such asteroids or to destroy them if they should pose a danger to life on Earth.

Albeit much of the public assumes that NASA and the military have this issue under control, NASA lacks the funds to take it on and the military has little interest. Even if the military were to adopt it as a mission, they met with considerable resistance from the Clinton Administration, which viewed military interest in this area as a ruse for wanting to develop an anti-satellite capability. After the discussion about asteroid 1997 XF11 (and its possible impact collision course with Earth that was shown at a later date to be erroneous) and the 1998 films *Deep Impact* and *Armageddon,* congressional interest was spun up again and another set of hearings were held. The result was to increase the annual budget for Near Earth Object (NEO) detection from $1.5 to $3 million.

The various roles that congressional members assume on space policy are variations on a theme of those more generally played in public policy. Concomitantly, the differences between space and other areas of public policy are significant and to a large degree permit the casualness with which members can choose to deal or not deal with the issue.

CONGRESSIONAL VOTING ON SPACE POLICY

The literature that explains congressional voting is based on leadership, constituency, and political orientation factors. Leadership is expressed as a concept of cue-taking based on a strategy of turning to political colleagues (i.e., congressional committee leaders and the President) for cues as to how to vote.[40] This approach is based on the assumption that legislators must cut information costs to reach decisions that further their policy goals.

Constituency pressures deal with reelection and electoral consequences, such as possible electoral defeat, as the key predictors of congressional policy action.[41] These consequences drive congressional decision-making towards a self-interest axiom. Members act to enhance their electoral prospects by voting in accordance with constituency concerns (e.g., support space projects on the basis of how it economically benefits the specific House district or Senator's state).

Political orientation approaches are based on past behavior and ideology as predictors of voting outcomes. Past behavior is rooted in a

process of political incrementalism.[42] Ideology, such as conservatism-liberalism, becomes a prime determinant of congressional voting when a member's policy and constituency positions are incongruous.[43] This takes place when policy preferences override constituency concerns.

Studies on House and Senate voting behavior comparing the relative impact of constituency preferences and ideology on defense, energy, and environmental policy find that ideology is a central determinant of voting outcomes.[44] These studies indicate that an inverse relationship exists between ideology and constituency factors. On relatively complex issues where constituency preferences are weak, such as in defense policy (space policy is assumed to be similar in this regard), political ideology is a better predictor of voting behavior than constituency pressures.

The way in which leadership, constituency, and political orientation factors interact and vary in the decision-making processes depends on the nature of the policy dimension.[45] For example, congressional members first consider constituency. If constituency goals are involved, then voting takes place in accordance with those pressures. Cue-taking becomes the dominant predictor in cases where constituency goals are not involved. On issues of a complex nature, that are often not within the competence of the legislator, ideology becomes an important predictor.[46]

Congressional decision-making explanatory variables (leadership, constituency, and political orientation factors) are reflected in the constraints that Congress faces in its oversight of NASA and the US space program. These constraints include the technical nature of the space program, the dispersion of congressional power, presidential authority over establishing NASA programs, policies, and budgets, and the closed politics of space. Despite these constraints, the "opening up" of space politics to a greater plurality of actors and interests, and political incrementalism, as reflective of ancillary politics, allows for Congress to play a direct role in space politics and policy.

Technical Nature of the Space Program

Historically, the growing role of scientists in the public policy process, with the advent of the space race in 1958, has led to congressional reliance on expert technical testimony or advice. Since the science and technology of the space program is complex and difficult to comprehend, congressional members are inclined to focus on the space program's administrative effectiveness, geographic distribution, and the implications it

has for the future development of the social and economic institutions with which it interacts.[47]

Dispersion of Congressional Power

The dispersion of congressional power as a result of a fragmented congressional committee system has hindered Congress in its attempts to control NASA. In essence, NASA has been able to play one committee against another. In addition, the differing orientations of the various committees concerned with space have resulted in contradictory commands being issued to NASA. This dysfunctional aspect of a fragmented committee system has led to an incoherent space policy. Congress in its attempt to provide more leadership and policy guidance in space has the option of turning to committee leadership with NASA oversight responsibilities for decision-making. In other words, congressional committee cue-taking (i.e., congressional voting that is congruent with committee policy preferences) is also a variable in congressional decision-making.

Presidential Authority

Presidential authority in advancing space development and exploration goals, space policy initiatives, and budget recommendations must coexist with annual congressional authorizations and appropriations for NASA. This raises the prospect that presidential cue-taking (i.e., congressional voting that is congruent with presidential policy preferences) is another predictor of congressional voting behavior on space policy.

Closed Politics of Space

The closed politics of space is exemplified by a distributive space subgovernment characterized by a tripartite alliance among congressional political leaders, NASA, and the private aerospace-defense industry receiving NASA research and development (R&D) contracts. Such a subgovernment, at least in the 1960s, made critique of the space program politically controversial and enabled NASA to keep internal conflicts within the Agency and political conflicts with other agencies and the aerospace community from being taken before Congress.

"Opening Up" of Space Politics

As the political environment for space has become more tenuous in the post-Apollo era, the closed politics of space has "opened up." This is no better illustrated than by ISS politics.[48] The ISS generated considerable conflict and uncertainty as to program goals among governmental and nongovernmental actors within the space subgovernment arena. A complex pattern of decision-making emerged based on the nature of the decision and the specific actions of governmental authorities. Governmental actors (President, Congress, and NASA) dominated the process by setting the framework, providing options, and crafting resolutions. Organized interests, primarily NASA aerospace contractors, played an important secondary role when they perceived a serious threat to their economic interests. The expansion in the scope of conflict among these subgovernment political actors resulted in a dynamic and adaptive space policy process exemplified by the six major redesigns in the ISS program.

A strong space subgovernment is further undermined by the fact that studies have shown that constituency factors, such as economic benefits the space program affords to the aerospace industry, do not play a central role in congressional decision-making as conventional thinking would expect. An examination of congressional voting patterns on NASA budgets from 1961 to 1971 found that congressional members who received greater NASA R&D contracts in their districts and states did not support NASA's budget in significantly greater percentage than did other congressional members.[49] Other studies on House voting patterns on the space program, which compares the Apollo to the post-Apollo eras, found that constituency factors (as measured by NASA funding in a particular House district) have less of an impact on voting behavior than ideological concerns.[50] This suggests that constituency pressures in terms of economic benefits are relatively weak predictors of voting for space casting doubt on the hypothesis that only members from districts or states with large aerospace industries and facilities vote in favor of space programs. It should be noted that the dearth of studies regarding congressional voting behavior on space policy leaves open the question of the extent to which constituency factors play a role. At the very least, the implication is that political orientations impact voting behavior despite the distributive economic effects of NASA's programs.

Political Incrementalism

Political incrementalism is reflected in studies on congressional decision-making as it relates to large-scale NASA programs such as Apollo, Space Shuttle, Hubble Space Telescope, and ISS.[51] These NASA programs illustrate the way in which the complex technical nature of space projects lends itself to incremental decision-making.

Incrementalism occurs when the decision-maker lacks the information and knowledge to put forward space policy goals. The barriers faced by Congress, which were mentioned earlier, are mitigated by the emergence of policy outcomes incrementally over time. Incrementalism is a policy strategy that serves to allow congressional oversight (and even micromanagement) of NASA's space programs. It is a direct outcome of ancillary politics in space policy. This fundamental change in the dynamics of space policy enhances the role of Congress in formulating and overseeing implementation of the US civil space program. The implication is that congressional political support for space has over the course of the space age increased in importance causing NASA to become more attentive to congressional concerns and more willing to appease congressional space policy preferences.

THE FUTURE AND THE STATUS QUO

For the most part, Americans get what they want from the federal government. Without a focusing event or crisis, Congress prefers the policy status-quo (political incrementalism and ancillary policy) to policy change (revolutionary and primary policy). In a field such as space, which is clearly an ancillary policy issue at best, incremental status-quo policy-making is the norm. Although NASA, like the Air Force within DOD, enjoys the largest civilian space budgets in the US, it is by no means the only player (nor always a single-voiced player). NASA must share the "heavens" with other non-military governmental agencies such as the National Oceanic and Atmospheric Agency (NOAA) and the Departments of Commerce and Transportation. These other Agencies, however, tend to defer to NASA's programmatic wishes. Albeit there have been attempts to move beyond the "programs for programs sake approach" which has long affected NASA, success has been mixed. Not only are big programs embedded in NASA's organizational culture, but at least part of the reason for this stalemate is the strong force of inertia supporting the multitude of programs in place, often carefully distributed among the districts of key congressional players. Interestingly, when this cozy nest is disturbed, NASA and Congress can quickly become strong allies.

Under the Bush Administration (89), there was an effort to give US space programs– civil and military– a goal. It was to be a goal to which all programs would be tied, and achievements measurable. Its failure aptly illustrates the forces at work, and the lengths they will go to, not to have the status-quo rocked. Specifically, President Bush reactivated the National Space Council to be chaired by Vice-President Dan Quayle, from its dormant state since President Nixon. The objective of the Council was to move the US space program toward a clear and simple goal. The "activities" involved under the Bush Administration were basically that of SEI, a strategy initiated outside NASA to focus US space activities on Moon and Mars exploration.[52] From many outside accounts, direction was the key element missing from the US space program. The DOD was even included in that effort in that it was decided that exploration initiatives have historically had a better record of success when the military is involved.

The idea for an SEI-type program dates back to the 1969 Space Task Group report called for during the Nixon Administration. This report was followed by the 1986 National Commission on Space study, *Pioneering the Space Frontier,* a 1987 report authored by former astronaut Sally Ride entitled *Leadership and America's Future in Space,* and a 1990 *Report of the Advisory Committee on the Future of the US Space Program* authored by former aerospace executive Norm Augustine. These studies advocate direction for the US space program to include human exploration of the Moon and Mars. Despite this policy guidance, the actual fleshing out of an SEI program was left to a mid-level bureaucrat from outside NASA with little experience in space, Mark Albrecht. A former congressional staffer with a background in national security and intelligence, Albrecht had the dubious honor of serving as Executive Secretary of the National Space Council. Although well-intentioned and capable, he was fighting insurmountable forces, primarily the inertia of political incrementalism stated earlier. Only half-heartedly backed by President Bush and Vice-President Quayle, he had the task of selling Congress this space exploration program that Congress clearly did not want.

Moreover, Albrecht not only got no help from NASA, he often found the Agency to be an obstacle. NASA was acutely suffering from the "not-invented-here syndrome" concerning SEI. Further, NASA was having acute pangs of parochial protectionism as it viewed the National Space Council, rightly, as an attempt by the White House to take back the space policy making initiative from NASA and Congress, which had jointly assumed the role as "place filler" since the Reagan Administration. NASA Administrator, Richard Truly, was especially hostile, since, as a former astronaut, he was known to have little interest in anything not involving the Shuttle.

NASA's response to President Bush's announcement of the SEI program concept made in a July 1989 speech commemorating the 20th Apollo lunar landing was called the *Report of the 90-Day Study on Human Exploration of the Moon and Mars.* Initially, there had been the hope that NASA would use this opportunity to move beyond the "good old days" nostalgia and methods of operation. Such a move, however, was not to be. To satisfy Truly's quest to fly the Shuttle, NASA's plan called for 14 flights per year in support of the program (more per year than NASA has ever flown), and then went on to incorporate everything NASA had ever dreamed of building. This effectively turned the "plan" into a policy disaster, as it had an accompanying price tag of $300 to $400 billion over thirty years.

After that, things went from bad to worse. National Space Council staffers covertly tried to get Truly fired. Truly and Quayle were publicly battling over the direction of space policy. Bush was noticeably silent, and in fiscal year 1993 congressional staffers who saw their own power bases being challenged by Space Council staffers apparently scrutinized the NASA budget actively looking for programs that even hinted of SEI so that they could be eliminated. The results are not surprising; the SEI program drained away, the National Space Council was again abolished after the Bush Administration (89) ended, and Mark Albrecht went off to be a corporate vice-President. The political challenge to NASA from the outside was gone.

As long as the status-quo is maintained, Congress seems content to remain mostly a benign benefactor. Occasionally, a newcomer will step in, determined to "fix" what nobody before him could. NASA knows that most of their efforts will be just new versions of an old tune, one that they need accommodate only until, as history has always shown to be the case, the congressional member's attention is diverted elsewhere.

The result is that Congress is not generally able to force coherent long-term change, nor does it really want to. Instead, legislative solutions tend to be across the board budget percentage cuts or caps to which agencies adapt to as best as possible. This often means a continual downsizing of programs, but not a pruning out or elimination of anyone's particular program. It also explains why NASA's programs, such as ISS today, are often over budget and behind schedule.

CONCLUSIONS

The difficulty in assessing Congress and space policy is that the process is evolutionary. What holds true today can change tomorrow. However, the basic motivations on which Congress premises its activity within the political process as well as the roles it assumes remains more static

and incremental. Once one has an understanding of those basics, it then becomes relatively simple to check a current congressional directory for the space related committee structure and membership and update information about the general rules within which the committees work.

Without a fundamental understanding of the premises upon which Congress works and votes, analysis can become meaningless. The simultaneously good news and bad news is (good for analysts, bad for space development) that those motivations and roles are unlikely to change dramatically in the near future, hence further entrenching the policy status-quo. Congress may want to change the way things work, but more often than not the institutional forces of public policy work against that desire.

6
BUREAUCRACY AND THE SPACE PROGRAM

Howard E. McCurdy*

INTRODUCTION

In many ways, the "space program" connotes NASA. Within the whole realm of government funded space activities, however, NASA is just one part of a larger space bureaucracy that exists in the United States (US). A sense of its scale can be grasped by examining the *Aeronautics and Space Report of the President,* issued annually through the NASA History Office. This space bureaucracy includes, in addition to NASA, the military space bureaucracy, and other executive branch departments.

NASA is the principal, but not the sole agency in the US responsible for space and aeronautics activities of a non-military nature- the so-called civil space program. Its employees organize space expeditions, commission the construction of satellites, design and operate a variety of launchers, and create facilities like the International Space Station (ISS). At its field installations, NASA scientists carry out research on a variety of subjects such as astrobiology and issues pertaining to aeronautics.

Since the early 1980s, military and intelligence space activities equal those of NASA in scale. This important trend is shown in Figure 6.1 as a measure of US federal government space outlays. The principle organization for the conduct of military space activities since 1982 has been the Air Force Space Command. As in NASA, officials working for the Air Force Space Command operate their own launch vehicles and spacecraft. The most important spacecraft they command fall under what is called the Defense Support Program (DSP). Automated DSP satellites can detect missile launches and nuclear explosions at the instant they occur, thus providing the technological backbone for the US military early warning system. Air Force officials operate a large constellation of military communication and navigation satellites, the latter providing the technology for the commercially utilized Global Positioning System (GPS). In addition, officials in the Navy and Air Force charged with the maintenance of the US strategic defense system maintain fleets of intercontinental ballistic missiles (ICBMs) that if fired from one point to another on Earth would travel through space. The

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Strategic Defense Initiative (SDI), a program conceived to defend the US against external missile attacks, has elements that could be based in space.

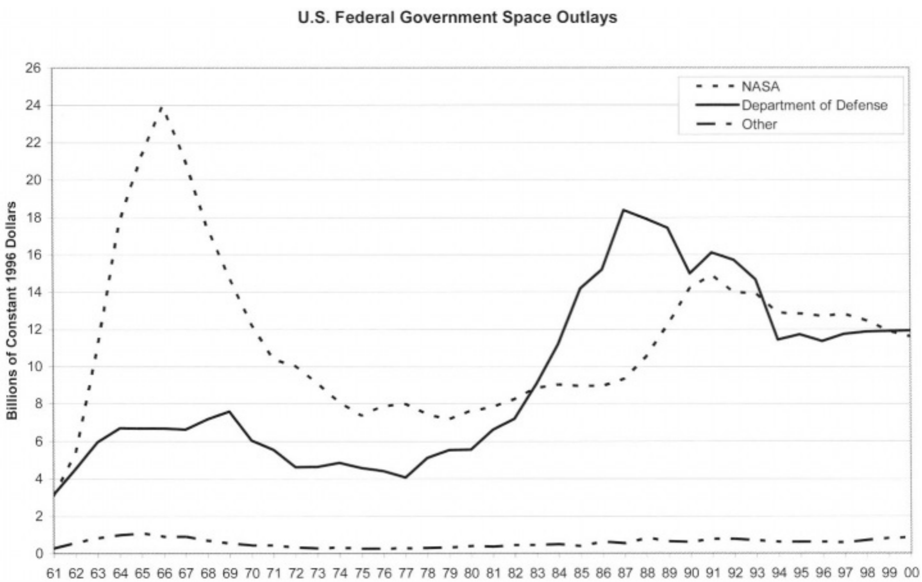

Figure 6.1. US Federal Government Space Outlays.
Source: Compiled by Eligar Sadeh and Trent Benisch.

During the first decade of space exploration, Air Force personnel prepared plans for a military astronaut corps and vehicles to carry them into space. A principal concept was the Manned Orbiting Laboratory (MOL), a space station structure that could be used as a reconnaissance and command platform. Air Force officers also considered the establishment of a military astronaut corps during the 1960s. Given NASA's politically driven domain over human spaceflight programs and the Air Force's preference for automated spacecraft, both these human spaceflight efforts were abandoned.

A third space bureaucracy of impressive size is tied to the US Intelligence Community. This Community joins NASA officials and their counterparts in the armed forces. It is centered on the activities of the National Reconnaissance Office (NRO), a top-secret agency created in 1960 at the height of the Cold War. The NRO has operated a succession of ever-more sophisticated remote sensing satellites capable of photographing objects on the Earth, piercing cloud cover and camouflage, and determining the material out of which potentially threatening objects are made; by studying the

composition of objects like tanks and aircraft, intelligence officers can estimate their capabilities. Other reconnaissance satellites eavesdrop on voice and visual communications. An intricate web of intelligence agencies, including the Central Intelligence Agency (CIA) and the National Security Agency (NSA), utilize information produced by these reconnaissance satellites.

The US space bureaucracy extends further. Even though their budgets are small by comparison to those of NASA and the national security community, the Departments of Commerce, Interior, Transportation, Agriculture, Energy, and State all play a role in the implementation of space programs. Officials in the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce, operate a number of satellites that monitor the biosphere. The US Geological Survey (USGS), Department of Interior, manages the Landsat earth resources satellite program in cooperation with NASA. Government employees in the Federal Aviation Administration (FAA), Department of Transportation, regulate commercial launches. Civil servants in the Department of Agriculture make use of global positioning and Earth resource satellite data in an effort to develop precision farming techniques. The Department of Energy provides NASA with radioactive materials for the radioisotope power generators that power some planetary spacecraft.

Lastly, the State Department assists in the negotiation of international cooperation agreements. There exists a network of space organizations that participate on major space undertakings beyond the borders of the US. Every major civil space activity has an international component. For example, the ISS is being built and operated by a consortium of sixteen nations including Russia. The multibillion-dollar Cassini mission to Saturn carries a Huygens space probe supplied by the European Space Agency (ESA), which is designed to parachute onto Saturn's moon Titan. The real organizations that manage civil space missions are often consortiums of civil servants from many nations and their respective space organizations.

BUREAUCRATIC POWER AND POLICY FORMULATION

People who work in these government organizations play a central role in the formulation of space policy. Bureaucrats within these strong and independent bureaucracies frequently initiate space policies. Once those policies are approved, civil servants usually enjoy a degree of freedom, what is called technical discretion, in policy implementation. The difficulty of conducting space ventures, along with the secrecy that accompanies national

security activities, has served to deliver substantial amounts of policy-making power into the hands of professional bureaucrats working within the executive branch of government.

Policy analysts often use what is called "principal-agent" theory to explain the relationship between bureaucrats and their political sponsors. From this perspective, bureaucrats are agents who carry out policies formulated by politicians, such as those elected to national legislatures. A similar doctrine, known as the "politics-administration dichotomy," suggests that policy implementation does not begin until elected officials formulate the policies that bureaucrats are expected to implement.

These concepts do not accurately depict the role of bureaucrats in the space policy process, certainly not in the US. In the realm of space policy, the relationship between principals and agents is often reversed. Civil servants advance the causes for which they are responsible, while elected officials exercise powers of oversight that can be likened to those commonly possessed by bureaucrats checking schedule and budget details. NASA career employees advanced all three of NASA's major human spaceflight initiatives: Apollo, Space Transportation System (STS), and ISS. The same is true for many space-related national security initiatives. Typically, career executives in the US bureaucracy win approval for new initiatives by constructing pockets of support within the Executive Office of the President. Staff support leads to presidential approval, which in turn is assumed to assure congressional authorization and appropriations. Experts do not view Congress, the law-making branch of the US government, as the primary body for initiating space policy.

Recent examples illustrate this process. In 1982, one year after his appointment as NASA Administrator, James Beggs appointed a Space Station Task Force at NASA Headquarters and told its members to formulate plans for a permanently occupied space facility in low-Earth orbit. During his confirmation hearings in 1981, Beggs, an aerospace executive and prior NASA employee, identified the space station as the logical "next step" for the civil space program.[1] NASA civil servants have been drawing space station plans since the agency was formed. Leaders of the Task Force defined space station requirements and worked to build policy alliances similar to those that had led to presidential approval of the Space Shuttle program one decade earlier. They sought support from aerospace executives, leaders of NASA field centers, scientific groups, space policy specialists in foreign nations that might cooperate on the venture, and officials in the Department of Defense (DOD).

With the space station, support from DOD was deemed to be especially critical. In anticipation of DOD support, NASA executives submitted their station plans to a newly created unit in the White House, part

of the national security apparatus, called the Senior Interagency Group (SIG) for Space. White House officials had set up this body in 1982 to review all civil and military space initiatives. NASA executives happily submitted their space station proposal to SIG with the expectation that it would receive DOD support, as had the STS initiative ten years earlier. Defense executives refused to endorse the space station, however, in part because they had grown disillusioned with the Space Shuttle and its military utility. Station advocates could not obtain a favorable recommendation for presidential approval through SIG.

Rather than abandon the effort, NASA officials appealed to another White House review council, in this case the Cabinet Council on Commerce and Trade. This was a sub-unit of the President's cabinet set up to review business initiatives. Supportive White House officials arranged a meeting in August 1983 between President Ronald Reagan and the heads of eleven US corporations, including four executives from companies that could expect to win contracts to help build the space station should one be approved. The executives told Reagan that America's aerospace business community needed a space station. Four months later, NASA officials presented their space station plans to President Reagan at a special meeting of the White House Cabinet Council on Commerce and Trade, a friendlier forum to NASA's interests than the defense-dominated National Security Council (NSC). One month later, Reagan directed NASA to begin work on the permanently occupied facility during his 1984 State of the Union address.

Even when a President or congressional member appears to initiate a space policy, bureaucrats often lay the groundwork for the cause. In history books, President Kennedy is credited with the 1961 decision to go to the Moon. This policy initiative, announced four months into Kennedy's Administration, was not conceived in the oval office. Special NASA study groups had been preparing plans for a lunar expedition for nearly two years prior to Kennedy's endorsement. NASA officials had asked Kennedy's predecessor, President Eisenhower, to authorize development of a Saturn-class launcher and a new space capsule that could reach the Moon. They made the same proposal to Kennedy in March of 1961. At first, Kennedy refused. A sudden event, the flight of Soviet cosmonaut Yuri A. Gagarin, the first human to orbit the Earth, helped to change Kennedy's mind. Following Gagarin's 12 April 1961 orbital flight, Kennedy asked his White House advisers to identify a space race accomplishment at which the US had a fighting chance to beat the Soviet Union. A NASA civil servant, Wernher von Braun, head of the Marshall Space Flight Center, drafted the critical response: "We have...an excellent chance of beating the Soviets to the first

landing of a crew on the Moon."[2] Such a feat required the development of the large space launcher that von Braun had been pressuring his superiors to fund.

Traditionally, the space bureaucracy has extended itself beyond government into private industry. The line between government bureaucrats and industry officials is not always clear. Employees of private aerospace firms build most government-funded space hardware. For most of the twentieth century, government contracts provided the primary source of business work; not until 1997-98 did business revenues from private sources, primarily in telecommunications satellites, begin to exceed government spending on space. Executives often move with relative ease between government agencies and business firms in the aerospace field. This practice is known as the "revolving door." Although congressional lawmakers have tried to discourage this practice in recent years through federal conflict-of-interest laws, the practice characterizes the space field to a considerable degree. As a consequence, aerospace executives who happen to work in the private sector initiate some government policies.

The origins of President Reagan's SDI provide a good illustration. For many years prior to Reagan's acceptance of the initiative in March 1983, officials in the national security bureaucracy spent money on missile defense initiatives. Spending continued even after 1972, when US leaders signed the Anti-Ballistic Missile (ABM) Treaty. Under the treaty, US and Soviet leaders agreed not to deploy any large-scale missile defense. That did not prevent them from conducting research or investigating counter-measures should one side decide to abrogate the agreement.

The concept of missile defense had been championed for many years by experts within the US Army, who might be called upon to defend US missile fields should the technology of defense prove feasible. As US political leaders established limits on missile defense, proponents of the concept retreated into private industry. Two of them, Karl Bendetsen and Daniel Graham, formed a group to lobby President Reagan's campaign team during the 1980 election and the White House staff after Reagan's inauguration. Bendetsen had served as Undersecretary of the Army and Graham as Director of the Defense Intelligence Agency. They found support among a number of key White House officials, most importantly, Robert "Bud" McFarlane, a member of the President's NSC staff. McFarlane was a career military officer, with 20 years of service in the US Marines; Graham had served 30 years in the US Army.

As a general rule, any new weapon system requires the endorsement of the top military hierarchy. Missile defense proponents worried that a different faction centered in the US Air Force– people who favored offensive missile build-up instead of defense– had captured the military bureaucracy. The Bendetsen group was so worried about the strength of this faction that the

group proposed a separate agency outside of DOD to pursue the defensive alternative. The group met with Reagan and McFarlane and extracted a vague commitment of support for additional research from the Joint Chiefs of Staff. From that opening, the space-based SDI was born. SDI was a product of lobbying by executives from the aerospace business community whose strength arose from their prior employment within the military bureaucracy.

Executive Review

The potential presence of conflicting viewpoints among so many executive agencies prompts the creation of formal coordinating mechanisms. In general, White House assistants insist that career bureaucrats resolve most points of disagreement before presenting policy decisions to the President. In that manner, the President's attention is focused on one or a few outstanding issues. Most students of politics understand how a bill in Congress becomes a law, but the process by which disagreements are resolved through the President remains mysterious. Unlike Congress, where committee jurisdictions and law-making procedures remain relatively fixed over time, the structure of presidential policy review tends to shift frequently. Review bodies come and go and their operation changes with the personal style of each new President.

The President's executive office alone includes career analysts, such as the people who staff the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP), and a large number of aides who come in with each new administration. Executive departments frequently detail their own employees to executive office staffs, from where they are expected to keep departmental leaders informed. Some executive office employees favor space activities; yet, far more view multibillion dollar space initiatives suspiciously since the spending intrudes on other public policy priorities.

A major space initiative is likely to draw the attention of the NSC, officials in OMB and OSTP, the President's science advisory staff, special assistants to the President with responsibility for domestic policy, the people who coordinate cabinet meetings, and the Office of the Vice-President, on which many Presidents have relied for the coordination of space policy. Beyond the White House, it is likely to enlist responses from people in a large number of executive departments and agencies.

To people promoting a new space initiative, the assembly of executive agencies and White House officials creates a potential for disagreement that is very hard to control. As a general rule, policy

formulation must survive a full review by some coordinating body representing all of the departmental and presidential personnel with an interest in it. White House aides never rely upon the President's Cabinet to do this; new space policies are inevitably submitted to review bodies of a narrower specialized scope.

Throughout the history of the endeavor, presidential assistants have relied upon an assortment of mechanisms to review space policies.

> *Special Advisory Committee under the leadership of the President's White House Science Adviser.* Prior to the creation of NASA, President Eisenhower relied upon the newly created office of White House science adviser to formulate national space policy.
>
> *Space Council under the leadership of the President.* The National Aeronautics and Space Act of 1958, which created NASA, required the President to establish a National Aeronautics and Space Council similar in form to the NSC. Congress directed the Space Council to survey the aeronautical and space activities of all executive branch agencies and "develop a comprehensive program." The presidential-led Space Council quickly fell into disuse. Presidents simply do not have enough time to directly involve themselves in the arcane details of national space policy.
>
> *OMB under the leadership of the President's Budget Director.* OMB employees are responsible for reviewing all agency spending requests and formulating the President's budget. Analysts within the OMB are permanent employees who do not change from one administration to another, although the leaders of this agency (as well as all other executive agencies) often do change through the power of presidential appointments. President Nixon relied upon OMB analysts to review NASA's request to develop the Space Shuttle. The Space Council fell into political disfavor during the first year of the Nixon Administration, when its leader, Vice-President Spiro Agnew, proposed through the Space Task Group report of 1969 that the White House initiate a broadly expanded space effort culminating in a 1986 human mission to Mars. Nixon abolished the Space Council after the 1972 elections due to political differences with the proposed programs laid out in the Space Task Group report. The Space Council was not revived until President Bush in 1989.

Space Council under the leadership of the Vice-President. Shortly before the decision to begin the Apollo Moon project, Congress amended the National Aeronautics and Space Act to allow the vice-President to chair the Space Council. Vice-President Johnson played the leading role in staff analysis leading to Kennedy's lunar decision. The special role of the Vice-President as the chief assistant for space policy was repeated by Presidents Nixon, Bush, and Clinton. President Bush (89) utilized the Council as a mechanism to develop the Space Exploration Initiative (SEI)– an unachieved policy that called for a lunar base and human expeditions to Mars.

OSTP under the leadership of a Presidential appointed Director. The OSTP was established in 1976 to serve as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the government including policy direction for space. Its mandate is to lead an interagency effort to develop and implement sound science and technology policies and budgets; work with the private sector to ensure federal investments in science and technology contribute to economic prosperity, environmental quality, and national security; build strong partnerships among federal, state, other countries, and the scientific community; evaluate the scale, quality, and effectiveness of the federal effort in science and technology; and advise the President and others within the Executive Office on the impacts of science and technology on domestic and international affairs. The OSTP has been an influential advisory body for presidential space policy-making.

NSC under the guidance of the President's National Security Adviser. The NSC is a unit in the Executive Office established as a consequence of the unification of the armed services within the DOD shortly after the conclusion of World War II. It was the principal mechanism for advising the President on defense policy during the Cold War. Given the scale of defense and intelligence activities in space, as well as the geopolitical implications of civil space programs like the lunar landing, many departmental leaders favor policy review by the NSC staff. The SIG for Space, the formal review mechanism set up during the Reagan Administration, was advanced by national security experts as a

way of reducing the influence of the President's science and budget advisers on space policy.

Interagency working group under the leadership of the Vice-President. Even though President Clinton favored the tradition of vice-presidential leadership, space policy was not advanced through a recognizable White House council. Instead, Vice-President Gore reviewed and formulated presidential space policy using a less distinct interagency coordinating group. At times, the mechanism used for this coordination was the OSTP.

The institutional arrangements used for the review of space policy within the White House are very fluid. A single President may use different institutional mechanisms for different decisions. The same presidential assistants may funnel military and intelligence-gathering initiatives to one review body like the NSC and civil space initiatives to an entirely different process. Advocates of new initiatives from the executive departments generally seek out the most favorable venue for policy review, regardless of whether it is the most comprehensive. They may switch review mechanisms in mid-course, as space station advocates did during the Reagan Administration. To the extent that they pay attention to space policy, Presidents tend to avoid permanent review mechanisms like a National Space Council. Such a permanent review body would likely act as an advocate for increased space activities, a posture that conflicts with each President's preference for policy flexibility.

In fashioning mechanisms for the resolution of policy differences, White House officials balance the desire for presidential flexibility against the need for comprehensive review. The need for comprehensive review is real. Space policy proposals often emerge from the bureaucracy with contradictions that are incompatible. When NASA officials advanced the concept of STS for White House review, they wanted to build a reusable space shuttle with wings and a 60-foot long cargo bay. Wings like those on a commercial jetliner would provide the lift necessary to allow shuttle pilots to land on conventional airport runways. The 60-foot cargo bay was necessary because NASA needed to use the shuttle to build a modular space station, another policy initiative. NASA officials had hoped to launch the space station using their heavy-lift Saturn V launch vehicle, but budget cuts forced the cancellation of the Saturn V production line. To continue future (and unapproved) initiatives, NASA officials needed a shuttle with a large cargo bay.

Officials in OMB who reviewed the STS initiative suggested that the President might approve a smaller model, one with a 45-foot payload bay. NASA officials sought DOD help in blocking this alternative. National security officials were enticed by NASA's promise of low-cost, easily available access to space, especially the suggestion that the Shuttle could be available to deliver reconnaissance satellites into orbit over the Soviet Union on short notice. Defense department executives contemplated a policy by which NASA's STS would become the principal launch vehicle for all large military payloads.

To launch large reconnaissance satellites, military officials needed a 60-foot cargo bay. This perfectly fit NASA's plans for the vehicle. But military officials also needed what they called cross-range capability– the ability to take-off from the coast of California, fly over Antarctica, maneuver a satellite over the Soviet Union, and return to California by way of the North Pole. That required a shuttle with delta-shaped wings.

Space policy review frequently involves engineering details such as these. Without comprehensive review, conflicting requirements may not be resolved, creating projects that cannot be carried out as conceived. President Nixon approved the Space Shuttle. He gave NASA officials the 60-foot payload bay they desired, but the Shuttle emerged from the review process without the delta-shaped wings that DOD required. Consequently, the Shuttle can land at only a few specially designed airfields.

Maintaining Support

Once space programs are underway, someone has to maintain the political support necessary for their implementation. This responsibility typically falls to people in the bureaucracy. NASA officials conducted various legislative campaigns to save ISS, prevailing in one case, in the US House of Representatives, by a single vote. Campaigns were led by a succession of NASA Administrators, assisted by career employees from the Agency's office of legislative affairs. White House officials provided support, but the primary effort was based in the NASA bureaucracy.

Administrative leaders use a number of techniques to maintain support for approved initiatives. They widely distribute monies allocated. Most of the money that space bureaucrats receive for space-based initiatives is redirected through installations in the field and from there to aerospace firms that produce operating systems and the hardware. The so-called "space crescent" of high-tech NASA field installations that passes from Florida through Alabama, Mississippi, and Louisiana to the Johnson Space Center in

Texas was deliberately created by national officials as a means of reshaping the rural economy of the South. Ninety percent of NASA's budget moves from field installations such as these to a network of aerospace contractors, universities, and subcontractors that stretch throughout the US. The resulting complex creates a widely distributed base of support that is hard to displace once a space program is underway.

Agency leaders consult frequently with groups that represent the people who benefit from government space activities. They consult with associations representing aerospace industrialists, scientists who fly experiments in space, engineers who design and build space systems, and a number of professional societies and grass-root advocacy coalitions such as the American Astronautical Society, American Institute of Aeronautics and Astronautics, Mars Society, National Space Society, and Planetary Society.

Space bureaucrats maintain close ties with the members of congressional committees that authorize their programs and appropriate their funds. Congressional oversight of space policy is fixed institutionally but is somewhat uncoordinated. Separate committees review proposals for military, intelligence-gathering, and civil space activities, and their jurisdictions change slowly if at all. Fragmentation of responsibility continues within the budgetary realm. NASA funding in the US House of Representatives moves through an appropriation subcommittee that also reviews spending plans for urban housing, environmental protection, and veteran's affairs, while government spending for military space systems moves through a separate subcommittee. For all its fluidity, space policy review in the White House is far more comprehensive than congressional review. In part for that reason, congressional review tends to be reactive rather than proactive, with space bureaucrats informing and nurturing congressional legislators as a way of maintaining momentum for programs underway. In general, congressional members of authorizing committees tend to be more supportive of existing initiatives than legislators on appropriation subcommittees, who must fund programs.

Finally, space bureaucrats build alliances with their counterparts in other space agencies. As the first American to orbit the Earth, astronaut John Glenn rode into space on a rocket built by Air Force officials who were preoccupied with the delivery of nuclear warheads. The Hubble Space Telescope uses optical technology originally designed for the NRO. Civil space officials in the US commonly formulate international agreements with officials in foreign countries, in part to broaden their base of support. An agreement with a foreign government to cooperate on a space mission provides a layer of protection not afforded by a domestic enterprise. International agreements are harder to break than domestic commitments,

given foreign policy concerns and international obligations, and engender a tendency within Congress to defer to the President.

Political scientists characterize the resulting network of alliances as policy subsystems, subgovernments, or the "iron triangles" of American politics. This refers to the distinctive three-way relationship that emerges between bureaucrats, congressional members of supporting legislative committees and their staffs, and advocacy coalitions that represent beneficiaries. The goal of people in this tripartite alliance is to control as much government activity as possible within their area of policy interest without external political interference.

In sum, people in the space bureaucracy play a critical role formulating policy and maintaining political support. Regardless of the US Constitution, professional bureaucrats play a leading role in space policy formulation. They depend upon White House review and presidential support for program approval, and develop subgovernment alliances for maintaining and protecting space initiatives once the President approves them.

BUREAUCRATIC POWER AND POLICY IMPLEMENTATION

As formidable as they are, the challenges of space policy formulation can appear trivial compared to the difficulty of making the policies work. Space policy implementation is rocket science; it is terribly complicated. NASA and the military space bureaucracy are high reliability organizations in that they deal with high-risk complex technological systems that are prone to failure and must do so in a reliable way that ensures safety. Launchers explode and spacecraft disappear. No one wants to suffer the indignity of failure. "Good enough for government work" is not good enough for machines within which thousands of components must work in tandem for a mission to succeed. The people employed by spaceflight agencies typically do not think of themselves as bureaucrats. Space agency employees view themselves as workers on the post-bureaucratic, high technology frontier.

Government employees laboring on space projects have developed methods of implementation that go well beyond the procedures typically found in other government organizations. Rather than chase efficiency, the traditional bureaucratic goal, workers on the space frontier seek to construct complex systems that operate reliably and safely. The methods they use to achieve high reliability in the face of considerable risk are intricate and often expensive.

Project Management

Bureaucracies are ill-suited to handle the problems of risk that arise within space-related technologies. By definition, bureaucracies are organizations that rely upon legions of career employees to apply written rules (standard operating procedures) to situations anticipated in advance. For routine, predictable operations, bureaucracies are technically superior to nearly any other form of organization. Where rapid change and technological complexity intervene, the advantages of the bureaucratic form can be problematic in the implementation process.

For the development of space systems, experts turn to a type of organization known as project management. Where a bureaucracy is permanent, a project is temporary– persisting only as long as needed to complete the mission. Bureaucracies tend to be hierarchical, while project teams tend to be decentralized. Project managers, located outside the conventional institutional hierarchy, often draw upon experts who work within the hierarchy, but only for so long as their assistance is needed. Project management was pioneered during the Second World War on activities like the multibillion-dollar Manhattan Project, the crash program to develop the atom bomb. By itself, project management is a necessary but not sufficient condition for preventing failure on complex space missions.

When the civil space program began, NASA engineers adopted the project management approach. Project Ranger, conducted by NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, provided an early test of the approach. Ranger was established to provide the first close-up pictures of the Moon, an important prelude to the selection of landing sites for the Apollo astronauts. JPL employees were told to design a robotic spacecraft that could transmit pictures as it sped toward a crash landing on the lunar surface.

Officials within JPL created a small project management office to coordinate the mission. The project manager drew expertise both from line departments at JPL and from US Air Force officers who provided the Atlas-Agena launch vehicle. However, the line departments at JPL resembled academic departments that were independent and often uncooperative. The project manager did not have sufficient authority to control the divisions. Neither could the manager secure adequate cooperation from the US Air Force. The subsequent lack of coordination showed up once the spacecraft flew. While attempting their first trajectory correction maneuver, project officials discovered that somehow a sign common to both the ground and flight software had been reversed. When flight controllers attempted to change the spacecraft's course, their command caused the spacecraft to go in exactly the opposite direction.

All six of the first Ranger missions to the Moon failed. Rangers 1 and 2 fell back to Earth when their upper stage rocket engines failed; spacecraft computers on Rangers 3 and 4 failed; the power system on Ranger 5 failed, accompanied by another computer failure; and the television cameras on Ranger 6 failed. Congress launched an investigation and NASA Administrator James Webb threatened to close JPL unless it adopted appropriate management reforms. Not until the summer of 1964 did JPL carry out its first successful Ranger mission.

Similar problems affected the effort to dispatch humans to the Moon. Webb believed that the implementation problems were a result of poor management. For example, when Webb's chief assistant for human spaceflight appealed for more money for Apollo instead of management reform, Webb fired him and brought in systems management expertise from the Air Force ballistic missile program.

Systems Management

The US Air Force developed the modern approach to spaceflight implementation. It combined project management with a new procedure called systems management. During the 1950s, Air Force officers engaged in a crash program to develop and deploy the first ICBMs capable of delivering nuclear warheads to targets across the Earth. These rockets were subsequently used to launch the first US astronauts into orbit as part of NASA's Mercury and Gemini human spaceflight programs. Management techniques developed for the ICBM program affected space policy implementation around the world.

In the beginning, Air Force missiles failed with statistical regularity. About half of the missiles exploded or otherwise did not perform as planned. The need to quickly deploy US missiles in order to meet the perceived Soviet threat compounded this problem. In order to meet schedule targets, Air Force officers were obliged to design launch and operational facilities before they had mastered rocket reliability. This requirement, known as "concurrency," meant that changes in rocket design continued as the construction of operational facilities proceeded. The people working on operational facilities made design and construction decisions before they knew the final configuration of the missiles those facilities would hold. A similar requirement affected the people working on Project Apollo, who were told to rush to the Moon in an equally unimaginable time. The consequences in both cases were implementation problems of complexity and high-risk systems prone to failure.

Sociologists like Charles Perrow have studied the nature of failure in complex systems such as these. Engineers can generally identify the individual points at which a rocket or spacecraft is likely to fail and build in safeguards so a single-point failure does not doom the whole mission. They may install redundant counterparts for critical components or isolate them in such a way so that their failure does not reverberate throughout the system. Most space missions do not end prematurely because of single-point failures. They end because two or more components interact in unexpected ways– the unanticipated consequences of complex technological systems. Engineers call these "interactive failures." They are the most troublesome challenge in spaceflight implementation. Interactive failures tend to occur very rapidly in mission-threatening ways.

The flight of Apollo 13 provides a vivid example of an interactive failure at work. While in space, astronauts need oxygen for breathing and often for electricity (oxygen and hydrogen will produce electricity when fed through a fuel cell). Held in a spherical tank in the weightless environment of space, the ultra-cold, liquid oxygen must be heated and stirred. During the preparation for the flight of Apollo 13, at the launch facility, a technician changed the electrical power voltage powering the heating coils inside the liquid oxygen tanks. Due to an oversight, no one tested the effect that excess electricity might have on either the thermostats that regulated the heating coils or the wires that fed electricity to the coils and fans. During a launch site test, the excess power caused a thermostat to weld shut and probably burned insulation off the wires. Technicians filled the tanks with liquid oxygen and launched the astronauts toward the Moon. When the astronauts routinely stirred the oxygen, one of the tanks exploded. The crippled Apollo Command Module spacecraft had neither enough electricity nor oxygen to return home. A modest change in a single component produced a disaster that nearly caused the astronauts to die in space.

To mitigate against the possibility of failure such as this, NASA executives recruited military officers and corporate executives who had worked on the Air Force ICBM program. These people imposed strong systems management over NASA's project practices. They established a large system engineering and integration office at NASA Headquarters in Washington DC. Office employees oversaw the work of project and subsystem managers at NASA centers in the field and the contractors that supported them. They instituted a number of organizational techniques and systems. This included configuration control that tracked the effect of design changes on other spacecraft and rocket components as well as on project schedule and cost, a system of progressively more detailed design freezes, and procedures for design certification reviews, change control, schedule analysis, control boards, engineering documentation, and responsibility accounting.

They marched rocket and spacecraft designs through formal reviews of ever increasing specificity, followed by exacting investigations to ensure that manufactured hardware conformed to design plans and flight readiness.

NASA lost only three astronauts on flight related activities during the Apollo years, the result of a fire during an all-up test of Apollo on the launch pad (Apollo 204). The flight of Apollo 13 was as close as NASA came to losing any astronauts in space. Albeit the trips to the Moon were triumphs of technology, the management reforms that made them possible were profound. In fact, space activities taught humans how to manage very complex undertakings.

Bureaucratic Culture

Experts agree that people in government organizations can conduct missions at high levels of reliability. The early history of the space program supports this point of view. Concomitantly, experts disagree about the length of time that such levels of reliability can be maintained. Pressures to economize and the ever-present burden of bureaucracy tend to erode pockets of reliability. People in space agencies operate risky technologies that can fail in thousands of spectacular ways. Organizations that achieve high levels of reliability through management reform can easily slip back to conventional and often more dangerous methods of operation.

The loss of Challenger provides a vivid illustration of this trend. Challenger exploded on 28 January 1986. The explosion occasioned an outpouring of books and reports critiquing NASA management practices. Members of the presidential Commission set up to investigate the Challenger accident concluded that the explosion was rooted in management practices that were fatally flawed. The investigating Commission (named the Rogers Commission after its chair William Rogers) produced a detailed report on the policies and decisions that contributed to the accident. From a technical standpoint, Challenger exploded when hot exhaust gas escaped through O-rings on the sides of the solid rocket boosters. In a sound system management organization, commission members agreed, concerns about such a potential fault would have been widely reviewed. The fact that no one at the Marshall Space Flight Center communicated concerns about the O-rings to persons engaged in STS flight review disturbed commission members. Procedures established during the Apollo era would have elevated such a concern. Those procedures had disappeared by the time the Challenger flew.

Why did NASA abandon management practices that seemed so essential to the success of technically complicated missions? The definitive

work on that question was produced by Diane Vaughan, a sociologist with little training in engineering technology but much understanding of human behavior and complex organizations. Vaughn produced a book in 1996, *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA,* which investigated the Challenger accident in excruciating detail. This book challenged the conclusions of the Rogers Commission, which placed much of the blame for the accident on managerial procedures. Rather, Vaughan produced considerable evidence that revealed the existence of a cultural change in NASA characterized by the "normalization of technical deviation."

During the Apollo-era, NASA did not fly a mission until they could prove that the mission would likely succeed. The Challenger flew because none of the doubting engineers could prove that it would not succeed. This shift in launch philosophy all but guaranteed that an accident would occur. As Vaughan demonstrates, in the new NASA culture, flying with known risks was not deviant, but normal. It was not confined to the Marshall Space Flight Center, where the decision to proceed with the flawed boosters occurred. Although the propensity for secrecy among managers at the Marshall Center exacerbated the deviation from past practices, the new norm affected the entire NASA organization. Vaughan argues that the new approach resulted from pressures to economize and the need to maintain the illusion that human spaceflight on a fully operational Space Shuttle was safe when in fact, in the words of astronaut and commission member Neil Armstrong, the shuttle employed "a tender design."[3] In other words, STS was more of an experimental than operational launch vehicle.

Vaughn produces one astonishing piece of evidence, a chart representing data discussed by contractors and NASA engineers on the eve of the fateful launch. Contractors worried that cold weather predicted for the day of the launch would degrade the performance of solid rocket booster O-rings. Engineers from both organizations sought to recall all previous shuttle missions during which such anomalies had been observed. The data, which Vaughn translates into chart form, shows no visible relationship between joint anomalies and low launch temperatures. Discussion of the data reveals an error that any first-semester statistics student would recognize. Missing from the discussion was the experience of flights on which incidents had not occurred. Those incidents group into launches that in every case proceeded at temperatures of 65 degrees Fahrenheit and above. In all of the cold weather launches, the field joints failed in some way, a conclusion missing from an engineering discussion where non-anomalous launches were ignored. Vaughn treats this as a cultural phenomenon, a collaborative undertaking in which participants follow an unwritten script that affirms the assumptions they have made about the work in which they are engaged.

NASA executives subsequently restored many of the management practices that characterized the early years of spaceflight. The Challenger accident suggests that institutions conducting risky operations go through cycles of organizational erosion and renewal. Smoothing out the cycles is a principal challenge for managers working in the space policy field.

Faster, Better, Cheaper

Spaceflight officials in both the civil and military sectors spent a great deal of money during the early stages of the Cold War. The Apollo expeditions to the Moon– in the currency of that time– cost over $25 billion. This was a huge amount of money, the equivalent of some $150 billion in the value of year 2001 dollars. Military officers engaged in rocket and satellite programs during the 1950s are reported to have spent even more. After the first landing on the Moon, government funds available for spaceflight activities decreased significantly; people in the space policy field acknowledged that government and industry could have done far more if the cost were not so high. Hence, efforts to discover low-cost implementation techniques became important.

The decision to develop STS was defended on the grounds that it would cut the cost of space access substantially. At the time, the cost of transporting material to low-Earth orbit averaged about $1,000 per pound. NASA officials hoped to cut that by a factor of ten. As developed, the Space Shuttle costs about $400-500 million to operate every time it flies, or about $8,000-10,000 per pound for its maximum payload. Even adjusting for inflation, this is well above the cost goals set for the system at its conception. Part of the problem in reducing launch costs with STS lies in the bureaucrat meddling in the program (as well as the budget constrains faced by NASA) during the formulation stage that compromised the system and made it less than fully reusable. Further, once implemented the resources were not given to the STS program to make the system truly operational. It remained an experimental vehicle that is costly to maintain and operate.

Efforts at cost reduction in the US frequently collide with space age managers suffering from what space analyst Frank Hoban has called the "bag of gold" syndrome. People who watched Congress fund expensive activities like Apollo in the early days came to believe, according to Hoban, that "there was always more money available to solve problems or to make things better."[4] Project managers are rewarded for mission performance, not cost cutting. High costs may get criticized while a project is being developed, but once it successfully flies, most engineers believe, cost overruns will be

forgiven. All in all, government officials possessed plenty of clever ideas about cost cutting, but little motivation to implement them.

Government officials charged with implementing President Reagan's SDI inaugurated a new round of space policy cost reforms in the late 1980s. Critics of SDI charged that the undertaking would cost hundreds of billions of dollars to be effective. To mute criticism, SDI advocates proposed what they called the "brilliant pebbles" concept– a constellation of small, low-cost satellites that would use lightweight sensors to detect enemy missiles and intercept them. Although the concept was never implemented, it encouraged the propagation of a number of cost reforms.

One of the industry executives who had worked on brilliant pebbles, Daniel S. Goldin, became NASA Administrator in 1992. Within NASA, Goldin promoted a number of initiatives that required project managers to develop "Faster, Better, Cheaper" methods of spaceflight. Projects qualifying under NASA's low-cost Discovery Program, for example, had to move from concept to launch in less than three years with design and fabrication costs no higher than $150 million. A small allowance was added for launch costs and operations. Among the first missions to qualify and implemented successfully were an asteroid rendezvous probe, a satellite to search for frozen water on the Moon, and two Martian probes.

The most highly publicized project to emerge from this initiative landed on the planet Mars during the summer of 1997. The Pathfinder lander, with its Sojourner rover, bounced into public view after a seven-month journey from Earth. NASA conducted the entire mission, including lander, rover, launch, tracking, data analysis, and operations for $266 million, less than one-tenth of the inflation adjusted cost of the two Viking landers that NASA sent to Mars twenty-one years earlier. The whole program took 38 months from concept to touchdown, an exceptionally short period for a major planetary probe.

NASA managers proved that they could develop low-cost spacecraft when given that as a primary goal. Project managers for the Pathfinder mission did this by simultaneously attacking the factors underpinning cost overruns: technology, risk, and organization. Rather than develop expensive, handcrafted flight technologies, they purchased commercial off-the-shelf components and hardened them for the rigors of spaceflight. Lightweight components and technological innovations helped to cut launch and spacecraft costs.

The Pathfinder team took risks that most spaceflight teams would avoid. They abandoned the conventional method for landing on distant bodies, the retrorocket touchdown. Instead, project managers adopted an unproved landing technique by which the space probe, after breaking in the Martian atmosphere, bounced to a landing enclosed in a giant inflatable air

bag. The air bag allowed project managers to land at a much more rugged and interesting site (and hence riskier), the mouth of what appeared to be a large ancient river.

To further reduce costs, Pathfinder managers cut the number of people working on the project team. This contested the conventional view that complex planetary missions require thousands of middle-managing civil servants to design and fly the spacecraft. Instead of a large, multi-center organization driven by paperwork and systems integrators, Pathfinder managers created a small, cohesive team at a single field center motivated by a common understanding of project requirements.

The Pathfinder experience challenged one of the principal assumptions underlying space policy implementation: are large project organizations necessary to achieve reliability in the face of complexity? The Pathfinder managers, with their "Faster, Better, Cheaper" vision staffed by motivated young experts, may have discovered a better method.

This method of "team-based" management is based on a number of organizational characteristics that are discussed in *Faster, Better, Cheaper: Low Cost Innovation in the US Space Program* by Howard E. McCurdy.[5] The characteristics of "Faster, Better, Cheaper" management include:

> Co-location of the core project team at a single location as the principal way of promoting teamwork.
>
> Overall responsibility for the mission vested in a single core group.
>
> Protection of the project team from outside bureaucratic interference, whether from the annual budget process, the larger NASA bureaucracy, or NASA's industrial contractors.
>
> Empowerment of the project team to make rules and standard operating procedures regarding mission development and implementation.
>
> Direct involvement of team members with the spacecraft (i.e., a "hands-on" approach) to maximize the problem-solving capacity of the team.
>
> Development of team capacity through multitasking of team members.
>
> Fostering common goals among team members such as cost control.

> Informal application of systems management procedures by the project team based on peer review by team members.

"Faster, Better, Cheaper" techniques have also been applied to the development of the Space Infrared Telescope Facility, what started out to be a Hubble-sized space telescope before it became much smaller. Mission planners at NASA's Johnson Space Center have produced plans for a human expedition to Mars that might be conducted for one-third of the inflation-adjusted cost of the Apollo voyages to the Moon. The plan relies upon in-situ manufacturing plants that would generate the propellants needed for the return voyage while on Mars. Officials in the NRO are preparing to build a new generation of spy satellites that will be significantly smaller and cheaper than traditional models. Given the expected cost savings, NRO officials hope to launch two to four times as many satellites, deepening the ability of the US to monitor events around the globe.

Many people believe that small project teams can carry out modest space activities with diminutive budgets. Others worry that the approach will lead to failure if applied to large, complex missions where systems engineering is required. In 1999, four of the five "Faster, Better, Cheaper" missions dispatched by NASA failed, including three bound for Mars. Analysts attributed the failures to excessive cost cutting and unwillingness among project workers to embrace the new, team-based management techniques necessary to make cost-cutting work.[6] Most problematic were the failures to formulate and document team-based management techniques, and to effectively make use of systems management.

CONCLUSIONS: FUTURE CHALLENGES

Reducing the high cost of spaceflight remains one of the challenges confronting space policy experts in the twenty-first century. Whether this can be done with new types of management techniques like the team-based approach used for NASA's "Faster, Better, Cheaper" initiative remains to be seen. Many experts believe that team-based organizations can be used for small projects, but that elaborate, costly organizations like those used to implement Apollo will still be required for large-scale undertakings. If small-scale organizations can be used for large projects, it will be as revolutionary as the implementation methods that made possible the voyages to the Moon and other great accomplishments like the Voyager and Viking spacecrafts. This is one of the most important issues facing the bureaucrats and technocrats involved in spaceflight implementation today.

The role of government in the civil space realm is changing rapidly, and with it the types of government institutions needed to implement new policies. The commercial space sector, which did not exist when the first space missions began, is larger than the governmental space sector and growing fast. NASA executives spend a disproportionately large portion of their budget operating systems like STS, ISS, and a variety of space telescopes, functions that people in the commercial space sector are increasingly capable of administering. Many experts believe that NASA ought to get out of the space operations business and concentrate on the research that leads to new technologies and the conduct of expeditions (human and robotic) where no business firms have gone before. Additionally, as the commercial space sector develops, the need for government support and regulation will increase. Traditional research and development agencies like NASA are ill equipped to handle these sorts of functions. Defining the government role in space relative to the commercial sector is a major policy issue.

Throughout the twentieth century, people working for the military and reconnaissance sectors confined themselves to robotic flight. Many proposals for soldiers or reconnaissance officers in space surfaced, but none were implemented. This is likely to change. The US Air Force is interested in using shuttle-like vehicles to conduct aerial bombardment from space, most likely using kinetic energy rods– inert cylinders that fall to Earth like asteroids with explosive force. In addition, the military may purchase shuttle-like vehicles for use as troop transports, allowing rapid deployment around the globe. And, the intelligence space community desires to develop means for defending satellites from hostile attack.

The military space program is a stepchild of the US Air Force. Just as the Air Force emerged from the Army Air Corps one half century ago, some sort of space force may arise as a separate military institution. Some people envision an additional role for the military similar to that of the US Army Corps of Engineers on the American frontier, constructing bases and infrastructure in space and assisting with resource recovery. Defining the institutional status of national security space activities will preoccupy government policy-makers in the near future.

As space activities grow, so will the need for more extensive presidential review; today, space policy review at the presidential level is fragmented and irregular. Space occupies a position well below the Cabinet level. Just as the activities like agriculture, education, and the environment came to attain Cabinet-level status in the executive branch, so will space. At times, various Presidents have used the National Space Council as a policy review mechanism, but these bodies have come and gone with different

administrations. As space activities come to play a larger role in national affairs, politicians will rethink its status and the mechanisms for executive review.

Space activities require robust and competent government institutions. The institutions must achieve very high levels of reliability using technologies prone to spectacular and rapid failure. Executive Branch employees play a critical role in formulating policy, extending their responsibilities well beyond routine implementation. To characterize such institutions as bureaucracies disguises the demands placed upon them. The role of the Executive Branch in formulating and implementing space policy is critical to the success of government in this realm of space exploration and development of space.

7
PUBLIC ADMINISTRATION OF THE SPACE PROGRAM

Eligar Sadeh*

INTRODUCTION

Are democratic principles congruous with the public administration of large-scale technological research and development (R&D) programs that characterize many space projects? The origins of the answer to this question lie in the contemporary public administration debate between "pre-state" and "pro-state" conceptions of the state.[1] A pre-state perspective is based on the merging of democratic values and public administration with the former serving as a balancing mechanism to mediate issues among contending domestic policy factions.[2] This approach to public administration entails administrative decentralization, public and political accountability, and limits on administrative discretion. A pro-state perspective involves public administration as a distinct governmental enterprise involving centralization of authority, administrative discretion, and a professional public service sector.[3] This perspective emphasizes public administrative and bureaucratic efficiency. The emergence of the United States (US) as a public administrative pro-state characterized by a professional technocracy is a reaction to the industrial and technological revolutions of the nineteenth and twentieth centuries.[4] With the advent of government-directed mobilization of large-scale technological R&D programs, symbolized in many ways by the US space program, the ability of the state to force technological progress while maintaining the essentials of democratic values emerged as a political concern.

US President Eisenhower faced this administrative-democratic dilemma in formulating a response to the crisis caused by the Soviet launching of Sputnik in 1957. The superpower "space race" that followed made it as important for the US to force technological innovation and progress as to ensure "democratic" values of freedom and stability.[5] At stake was finding a way to compete with the Soviets in technology and science without sacrificing the essentials of US freedom and prosperity rooted in limited government involvement and private initiatives in R&D. To this end,

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Eisenhower fashioned a policy of state-directed mobilization of technology, while de-linking the military from the domain of space exploration and human spaceflight. These aspects of the space program were placed under civil public administrative control with the establishment of NASA through the National Space Act of 1958. NASA served as a political "smoke screen" for the military and intelligence space programs and the associated "technocracy" underpinning the US space program; for Eisenhower NASA represented democratic values of openness and public accountability.

Within the context of the civil space program, is the public administration of large-scale technological R&D programs versus one of ensuring democratic values of governance an either-or proposition? Based on the fact that democratic accountability and responsiveness are of paramount importance in the operation of public administration in the US, the answer to this question is no.[6] Rather than the notion of "principal-agent" theory or "politics-administration dichotomy," interconnections among these two entities, political sponsors (the principals such as the President and Congress) and bureaucrats (the agents or administrators such as NASA), are more the norm. Moreover, technology is a by-product of "heterogeneous engineering."[7] In the age of space exploration, technology may embody a universalistic approach to problem solving and the rational organization of sociopolitical behavior,[8] but the organization and administration underlying policy implementation must take place in the democratic political environment and structure that exists within the US.

The development and administration of technology is wedded to this larger sociopolitical context on the basis of three interconnected dimensions. The first dimension is a political one concerning democratic values of accountability, responsiveness, and representativeness. A second dimension is a technical one regarding the inherent characteristics of large-scale technological R&D space programs, and the related issues of reliability and technological innovation. The third dimension is the administrative one that pertains to organizational decision-making, technical rationality, and organizational cultures. NASA's administrative practices during the Apollo and post-Apollo eras, including the Apollo 204 and Space Shuttle Challenger accidents, serve as important case studies to identify how the three interconnected dimensions affect the public administration of the US civil space program.

POLITICAL DIMENSION

Accountability

Accountability involves the means by which public agencies manage the diversity of legitimate and conflicting expectations emanating from within and outside the organization.[9] From within the organization, accountability is technical and administrative. External pressures on accountability are evident in the organization's institutional and political contexts. There are three types of accountability systems that are pertinent for the space program: professional-technical; administrative-organizational; and institutional-political.

Professional-technical accountability is one of technical competence rooted in the principles of engineering and technology. Administrative-organizational accountability comes into play through organizational controls and structures, management practices, and standard operating procedures. Institutional-political accountability is the public accountability that is provided through presidential review and congressional oversight of policies, plans, and budgets. Public agencies mediate between professional-technical, administrative-organizational, and institutional-political accountability systems. The challenge for the organization is to find an administrative scheme than balances and harmonizes these three accountability systems.

Large-Scale technology presents a twofold challenge: manage technology while avoiding failure, and maintain capacity for meeting external political challenges. The former challenge is related to the inherent characteristics of technology and its impact on administration, and the latter is linked to public administration of technology within an institutional "democratic" context. This implies that a bureaucratic manager within NASA must deal with developing complex technology, properly account for technical competence and controls (management and organizational practices), and work within the confines of external political pressures and constraints that affect the organization's schedule and budgets.

The Challenger accident was in part a result of changing institutional pressures generated by the US political system. Changes in the external political environment towards the civil space program, from "primary" policy during Apollo to "ancillary" policy afterwards, resulted in a shift in the type of accountability systems. The shift from a dominant professional-technical accountability system to one that emphasized the institutional-political system is incongruous with NASA's technical oriented tasks. Political criteria eclipsed technical concerns in the decision-making process that led to the Challenger launch decision.

Responsiveness and Representativeness

Administrative responsibility entails responsiveness to popular sentiment and technical knowledge. At issue is how democratic representation and participation interact with complex expert-dependent technologies that characterize the space program. Representation implies that public officials are morally obligated to seek a mandate from their constituents, such as the advocacy coalitions that interact with space policy-making, and to reflect that assessment in public policy deliberations and actions.[10] The realization of representation in complex large-scale technologies is problematic since the administrative discretion and autonomy required for technological development has spawned a professional technocracy that is reliant on specialized experts and technical rationality.[11] This technocracy is exemplified by an administrative doctrine encompassing state-directed mobilization of resources and organization. During the Cold War, this doctrine entailed: space and military technological competition with the Soviet Union; the elevation of technical and scientific advice to the apex of governmental policy-making; governmental subsidies for basic R&D; and vast governmental expenditures on space and defense.[12]

Public administration of large-scale technology faces pressures of representation amidst the technocratic dominance and efficiency that is sought to advance technological progress and acquire technical knowledge. This dominance manifests itself in constraints to the public governance of technology. These barriers include technological illiteracy among the political sponsors and public, the dependence on professional (technocratic) elites that administer and mange the space technology, reliance on governmental and corporate capital that is mobilized to fund space technology, and the government-industry "contractual" relationship (the complex) that is applied to R&D the technology.

In this regard, the extent to which an organization reconciles democratic values of responsiveness with that of bureaucratic discretion required for public administration of large-scale technology is important to consider. There are three useful concepts on the public administration of large-scale technology that as a whole consider the nexus between "democratic" institutional pressures for representation and the need for administrative discretion and efficiency.[13] This encompasses the public choice, bureaucratic power, and corporate power concepts.

Public choice deals with the issue of representativeness in the promotion and development of technologies. This concept argues that Congress, as exemplifying representativeness, has the capacity for oversight and overview of the space program and its large-scale technological endeavors despite shortcomings in technical expertise relative to NASA.[14] Of

importance to Congress is information about the space program's administrative effectiveness and the implications it has for social and economic development. Oversight is made possible with the statutory provision to the National Space Act of 1958 that requires NASA to seek annual congressional authorizations and appropriations. Overview is possible in reviewing NASA's administrative practices dealing with policies, plans, and budgets. Public choice addresses the fact that in the US democratic system public accountability and acting in the public good are factors in the implementation of space technology.

Bureaucratic power deals with the extent to which NASA as a technology-intensive agency is independent and autonomous; the extent to which NASA has bureaucratic power despite the factors of public choice. Faced with the rapid expansion in the complexity of space technology along with the expertise that NASA possesses in this area, the issue of meaningful congressional scrutiny over administrative discretion is raised. Members of congressional committees overseeing NASA tend to accept space programs at face value. They are unable to comprehend the myriad of technical problems involved much less control their solution.[15] Congressional attitudes toward NASA are shaped more by politics and conventional interpretations of reality than by technical facts.[16]

Corporate power relates to the public-private (governmental-industrial) partnerships for the development of space technology. NASA depends on such partnerships to realize its technical tasks and to meet standards of reliability and efficiency (operations). However, the assumption that governmental partnerships with private corporations promote efficiency while retaining reliability is problematic when imperfections in the relationships are present. One important imperfection is a result of the different organizational cultures that exist between public and private organizations.[17] The culture of the public agency is to maximize bureaucratic efficiency and deal with issues of public accountability, while the culture of the private corporation is to maximize economic efficiency and a return on investment.

This imperfection between NASA and Morton Thiokol (producers of the O-ring, the failure of which led to the Challenger accident), which manifested in constraints on the flow of information and organizational learning between NASA and its contractor, played a role in the Challenger accident. NASA and Morton Thiokol engineers focused on solving technical problems, engineering managers were concerned with Space Shuttle operations, and NASA's top-management sought external political support.[18] The managers at Morton Thiokol placed the concerns of the engineers (technical accountability), who warned about problems with the functioning

of the solid rocket booster (SRB) O-rings in cold temperatures, second to the economic concerns that Thiokol had in maintaining governmental contracts for its business. Interestingly, Thiokol's concerns were reinforced by the political concerns of NASA's flight management team that sought to maintain a manifested Shuttle launch schedule,[19] and more importantly to ensure compliance with established rules (standard operating procedures) for Space Shuttle Flight Readiness Reviews and Launch Commit Criteria. This implied that technological accountability was of a secondary priority both for Morton Thiokol and for NASA.

State-directed technology development tends to promote scientific, professional, and administrative forces.[20] Democratic (and pluralistic) group processes, such as advocacy coalition politics, are curtailed due to technological complexity. Nevertheless, congressional pressures for democratic responsiveness and public accountability have impacted the space program. Moreover, the complex technical nature of space projects, and the barriers this posits before Congress, lends itself to incremental decision-making.[21] Incrementalism allows for public oversight on the basis of political factors that are not sensitive to technological claims.[22]

Congressional decision-makers do not have the technical knowledge to put forward R&D goals and objectives. In order to execute oversight of NASA, decisions are not on the basis of rational assessments of space technology and its value towards achieving space goals, but are rooted in the larger scope of congressional politics involving cross-pressures from advocacy coalitions and other domestic programs.[23] The fundamental design parameters of both NASA's Space Shuttle and space station programs were determined not solely by available space technology, but also by a blend of political, economic, and institutional concerns.[24]

In the post-Apollo era, NASA faces incremental decision-making pressures from Congress to redefine and redesign its programs. This leads to an ongoing cycle of program support on the policy agenda, authorization and appropriation (formulation of policy), design (implementation), opposition (policy change), and then reauthorization and redesign. Since President Reagan's endorsement of NASA's space station program in 1984, the program has received strong congressional support, followed by possible congressional termination, and then reaffirmed political support. At each phase in the evolution of policy, the space station was redesigned and scaled back in its technological scope and scientific missions. This has contributed to prolonged development cycles and to cost overruns that are an endemic part of the problems facing the International Space Station (ISS).

TECHNICAL DIMENSION

Reliability

Space technologies are characterized by complexity and uncertainty as manifested in the interdependence of components; any single-point component failure produces system-wide interactive failures in a complex technological system. Organizations mitigate against the catastrophic consequences of interactive failures by emphasizing reliability over efficiency as an administrative scheme. Reliability is defined as the probability that a technology will operate as expected for a given period of time. The inability to meet this expectation is a failure. By combining the reliability of individual components, the reliability of a complete system can be realized.

Reliability is achieved through component redundancy, duplication, and overlap. This is a fundamental technical feature of high-reliability organizations, such as NASA, that attempt to manage high-risk systems with reliability and safety (i.e., the standard operating procedures and monitors to ensure that no major accidents take place).[25] Concomitantly, institutional pressures and organizational factors can promote high-risk strategies for development and operations. NASA's predisposition for risk-taking and high-risk scenarios in the 1960s tended to enable technological advance at the cost of catastrophic failure. From 1958 to 1961, NASA's mission success rate was less than 50%.[26]

Once NASA was able to integrate effective management controls, in particular systems and configuration management techniques used successfully by the US Air Force in ballistic missile development programs, reliability and even degrees of efficiency in terms of meeting cost and scheduling constraints were achieved.[27] For example, with the development of the Saturn V, an organizational culture based on incremental testing and verification rooted in the Saturn V development team led by Wernher von Braun clashed with one of all-up testing favored by the military (systems management) culture brought into NASA. NASA's risk-taking organizational culture along with the political pressures to meet President Kennedy's goal of landing a man on the Moon before the end of the 1960s allowed for all-up testing to win out.[28] In the end, it was these organizational controls and management methods that were essential in enabling NASA to meet its lunar goal.[29]

High reliability organizations can commit two types of organizational errors in relation to the technology they manage.[30] First, organizations can implement the wrong policy or decision (e.g., NASA launches an unreliable, unsafe vehicle), an error of commission. Second, organizations can fail to act

even when action is warranted (e.g., NASA does not launch a vehicle that is technically reliable and safe), an error of omission. Reliability is employed to try and avoid these errors. In turn, reliability is affected by the capabilities of the technological system and by the structure of the organization. On the technical side, reliability was realized through the "culture of component redundancy" that was an inherent part of the engineering design philosophy.

Indicative of organizational restructuring is the case of the Apollo 204 fire. This fire, an error of commission, resulted from an imbalance between organizational and technical responsibilities.[31] NASA managers failed to communicate to James E. Webb, NASA Administrator during the 1960s, the organizational and technical problems between the Agency and North American (contractor for the Apollo Command Module). The aftermath of the fire led to Webb's reorganization of NASA's management structure as to improve Agency reliability and avoid errors of commission. NASA restructured its contractual relations with North American, lowering its profit for Apollo and placing North American's management of the Command Module program under the direct supervision of Boeing (the contractor responsible for systems integration of the Command Module, Lunar Module, and Saturn V).[32]

The Challenger accident was a function of an additional organizational restructuring that took place within NASA after the Apollo era. The restructuring was in response to the operational demands placed on the Agency with the Space Shuttle program. In order to meet operational demands, NASA emphasized decentralization over centralization as to avoid an error of omission.[33] The loss of strong political support for NASA after Apollo led to an emphasis on efficiency (operations) to the detriment of reliability. NASA was compelled to do more (implement a promised launch schedule) with less financial resources. These factors promoted an emphasis on avoiding the failure to act, increasing the chances for a wrong policy decision.

Related to this process of organizational restructuring is the bureaucratization within NASA. This leads to the satisficing of organizational decisions (the standard operations procedures established to mange the technological systems) both in reliability and in accountability systems. Satisficing behavior works to first and foremost realize bureaucratic operating procedures, like the flight readiness review procedures for the Space Shuttle, even when it may not be warranted. The implication of satisficing indicates that technical reliability is ultimately tied to organizational factors. This point is illustrated by Apollo 204 and Challenger.[34]

Technological Innovation

An integral component of public administration involves technological change or innovation. Technology can either be immune to political control and judgment or it is an outcome of these state-society relations. In the US, societal influences on the process of technological innovation tend to be more strongly felt than in other democratic states.[35] Through an examination of the process of technological innovation as applied to Apollo, the links between the political, technical, and administrative dimensions are highlighted.

First there is a process of technocratic initiative. The fact that NASA established technical plans for a Moon mission before political commitments were forthcoming indicates that Apollo was a result of a political institution capitalizing on an emerging set of technical possibilities.[36] Technical initiative emanates from the engineers and technologists tasked to a design project. Second there is a process of consensus building. Inherent in this process is the idea that technology is not an autonomous force shaping politics. NASA, for example, chose Apollo as a logical successor to project Mercury on which it had to reach a national consensus and legitimacy with the President, Congress, and the public.[37] Consensus building allows for political support and rationales to buttress what is feasible from a technical standpoint. The third part of the process is whereby the innovation is promoted to higher governmental levels. State-directed mobilization of space technology was set into motion with the establishment of NASA in 1958 and the Cold War. The fourth area is an open policy window of opportunity. Technological innovation often progresses if it is in response to an external threat (e.g., the launching of Sputnik and the Cold War), because the threat induces the government to mobilize sources that can "force" the progression of technology. Finally, high-level governmental endorsement is needed. This was forthcoming by President Kennedy with Project Apollo.

As is evident in this process, technological innovation is tied to the contextual issues of political appropriateness, internal issues of organizational capabilities, and autonomous technological change; technological change may have an inertia of its own, but if it is to be adopted it has to be congruous with external political factors such as perceived need and resources.[38] In the post-Apollo era, technological innovation, in terms of the ability to implement programs, was hindered by the external political environment and by the organizational response that bureaucratized NASA's technical capabilities. These aspects contributed to the problems that have been encountered in the Space Shuttle and space station programs.

Contrary to "technological determinism," the technical dimension

coexists with the political and administrative. In the final sum, Project Apollo was just as great an administrative feat as an engineering one. Apollo was technically feasible but not necessarily administratively possible, especially given the organizational crisis of the Apollo 204 fire and the structure of the of US democracy that constrains administrative discretion and autonomy.[39] The cases of the Space Shuttle and space station exhibit causal links between the political, technical, and administrative dimensions. In particular, the nature of the political dimension reinforces the negative traits of the other two dimensions.[40] This is especially true given the decision-making pattern of incrementalism that characterized the policy process of both programs.

Incrementalism is not necessarily a negative trait of democracy, but an inherent part of US politics. It tends to make it more difficult to manage cost and complexity factors of space technology development. Even though incrementalism may make implementation and administration of space technology more difficult, it does represent a political strategy employed to ensure democratic responsiveness in the public administration of large-scale technology. How to deal with this aspect of public accountability, which has negative consequences for technology development, is a challenge of the managing space bureaucrat.

ADMINISTRATIVE DIMENSION

High-reliability organizations tend to form managerial patterns that integrate centralization and decentralization.[41] Project Apollo combined intrusive planning and hierarchical organization with decentralization and flexible technology development processes. Bureaucratic processes overlaid professional-technical accountability systems that were embodied by project management practices. This ensured administrative-organizational accountability. NASA integrated the relatively autonomous technical and professional cultures within its field centers through a centralized management structure that applied the formal controls of systems and configuration management. Webb also created a management structure that was responsive to both the decentralized qualities of NASA's organizational culture and its external institutional-political concerns.[42]

In the post-Apollo era, NASA adopted a "lead-center" approach that emphasized NASA's decentralized organizational culture. The advocates of decentralization viewed local project control and project management as a means of favoring NASA's technical culture. This entailed the shifting of integration work on complex programs back to the field centers. Though, decentralization became a means whereby people in the field elevated bureaucratic barriers to cooperation and communication.[43] This led to overall

bureaucratization within the Agency as competition for resources and programs between the field centers intensified.[44] Professional technical accountability diminished as a result of this bureaucratization. Indicative of this is the Challenger accident.

Organizational Cultures

Technological development is linked to organizational cultures that infuse organizations with values.[45] High-reliability organizations that face critical and complex tasks are consciously value-driven.[46] Value overlays in NASA are reflected in its organizational cultures that are inextricably linked to public administration. The way in which an organization is able to administer its tasks is determined by its organizational cultures.

Within NASA two primary cultures are evident: competency and control.[47] Competency is the traditional R&D culture that NASA inherited from its predecessor organization, the National Advisory Committee for Aeronautics (NACA). This culture is a competency one characterized by an exploration ethos and its associated traits of cutting edge R&D, risk-taking, and institutional idealization.[48] It is practiced through an emphasis on professional-technical accountability and project management. Control is a militaristic culture that permeated NASA from its ties to the military and industry. This culture is imbued with controlling, through documentation and standard operating procedures, its in-house and contractor technical activities. Characteristic of such a culture are risk-aversion and systems and configuration management.

During the Apollo era, NASA balanced these two cultures by imposing a centralized management hierarchy, while administering in a decentralized fashion a technological innovative visionary goal (i.e., land a man on the Moon and return him safely back to Earth). In the post-Apollo era, NASA emphasized operations, a "mission to infrastructure." This task required a high-degree of reliability. The lack of an effective centralized management structure fragmented control within NASA and allowed for competency to emerge as a dominant culture among NASA's field centers. Fragmentation resulted in competition among these centers for their preferred technical competencies. Competition over competencies diminished the ability for administrative-organizational accountability and reliable control over technological systems.

Reliance on one type of culture over another can lead to problems in the public administration of space technology. A reliance on the competency culture can lead to interactive failures in that organizational controls are

misapplied to mitigate such failures. Project Ranger, which initially failed six straight times, as well as the recent Mars Climate Orbiter and Mars Polar Lander failures are a consequence of this reliance. On the other hand, a reliance on the control culture leads to satisficing behavior in that the organizational imperative, the standard operating procedure, becomes more important than ensuring full technical competence. This is an important factor that led to the Challenger launch decision.

Technical Rationality

NASA's task is to be technically rational; this is the essence of professional-technical accountability. Nonetheless, technical rationality does not exist in isolation, but in tandem with political and organizational rationality;[49] political and organizational rationality types condition technical rationality leading to a possible disjunction between task and organization. The Challenger accident emanated from such a disjunction where management in NASA was wedded to political and organizational rationality to the detriment of technical considerations. Technical rationality of large-scale technologies is paramount in policy success or failure. Of critical importance is the administrative ability to manage the cognitive, social, and political factors that "bound" technical rationality; technical complexity posits cognitive barriers; social constrains are organizational and bureaucratic; and political constraints are externally generated and institutional.[50]

An "unbounded" condition assumes comprehensive rationality where decision-makers have a well-defined problem, perfectly ordered preference-orderings, and full information about the consequence of each preference. For technical rationality, this is an ideal situation. Nevertheless, decision-makers are always bounded at some level. The comprehensive rational model is impossible to follow in any strict sense, for bounds on rationality come into play; the factors that bound rationality are part and parcel of any practical application of space technology development and operations.[51]

A case in point is how the technical culture itself can be bound. The engineering culture within NASA is based on a design philosophy of redundancy. This approach shapes how engineers ensure reliable and safe operations in the complex systems that they are designing. The problem in this is that the belief in redundancy can mask or hide problems that may exist in the design. In the Challenger case, there were engineers that questioned the design of the O-rings in the SRB joints, but even those engineers thought that the design of a secondary O-ring would prevent failure.

The bounds on technical rationality are manifested in the decision-making process that consistently normalized the "technical deviation" in the

Space Shuttle system.[52] This process of "normalization" entailed a cultural construction of risk.[53] The cultural construction of risk translated into decision-making patterns that accepted risk when the O-rings deviated from performance expectations. Engineering oriented norms and beliefs legitimatised work group decision-making on the SRBs; the technical assumptions about risk were seen as acceptable and "non-deviant" within the SRB working group. SRB engineers took for granted that both redundancy in component design and the standard operating procedures, which were in place for the Space Shuttle, ensured reliable and safe operations, an assumable risk to fly. Moreover, the patterns of information exchange and organizational structure perpetuated normalization of risk in the Shuttle system that concealed the seriousness of the O-ring problems.[54]

Cognitive limitations are imposed by the fact that groups within an organization aggregate preference orderings differently than as a system wide entity. In NASA's case, competing cultures have led to three setsof groupings within the Agency: institutionalists (top-management) concerned with external politics; managerialists (middle management or the bureaucratic manager) focused on public administration; and technical specialists (technologists such as NASA engineers) who deal with R&D of the technology. Each of these groups aggregate in ways that do not "value-maximize" the preference-orderings of any one particular group or the Agency as a whole. On this basis, technical considerations can lose out to managerial concerns and institutionalist preference-orderings as in the case of the Challenger accident.

Aspects of the cognitive constraint also come into play with Apollo 204. The technical failure in this case that led to the fire was a function of the sociopolitical power relationship between NASA and its contractor, North American. This power relationship manifested itself into cognitive limitations on the complex technology of the Apollo Command Module. Their existed information asymmetry and bounded technical rationality between NASA and North American. Essentially, NASA safety engineers overruled industry technologists, which had expressed concerns about the workmanship on and the quality of the Apollo Command Module hardware, because the information NASA had indicated that the hardware was safe.

In this case, all the information was in the administrative system fashioned by Webb. Problems about safety issues with the Apollo Command Module were properly inferred as well, especially as it relates to the issues of the then one gas (pure Oxygen) system. What was problematic in the Apollo 204 case was that Webb's system of checks and balances, and multiple channels of information upward to top-management did not work. That is, those responsible for managing the technology and for ensuring

organizational accountability failed to communicate to Webb the nature of the problems with North American and the issues of technical competence on the Apollo Command Module. What made matters even worse was that Webb's outside role directed at political accountability masked the extent to which attention could be paid to organizational responsibilities.

Social constraints emerge from the nature of organizational processes and bureaucratic politics.[55] These constraints are posited as options and choices faced by a bureaucracy and are reflected in satisficing behavior patterns aimed at fulfilling standard operating procedures. Groups that are part of the system will tend to follow these procedures since they are seen as the optimal organizational objective. Followed to its logical conclusion, the realization of standard operating procedures value maximizes group gain. Even when situations emerge that may call for a revision in the operating procedures, such as a new launch commit criteria due to the cold temperature relation to possible O-ring failure in the Challenger case, the procedures are followed. It takes a crisis, such as catastrophic failure, to bring about a rethinking of standard operating procedures.

Also, social constrains are a result of each group within NASA trying to advance its agenda at the expense of the other groups. This is mitigated by the emergence of policy outcomes incrementally over time. Incrementalism allows for the public administration of large-scale technology, among multiple actors with different preference-orderings, as both Space Shuttle and space station R&D processes exhibit.[56] Interestingly, incrementalism is not only promoted by democratic responsiveness, but also by these social constraints on administration.

Political constraints are reflected in how external political factors influence organizational decision-making. These constraints encompass public accountability and the impacts this has on cost and scheduling factors. At this level, the situation is more structured and less amenable to Agency manipulation. These constraints account for the unfavorable political climate NASA found itself in at the conclusion of Apollo and the emergence of detente. One way this has impacted technical rationality is by shifting risk-taking administrative strategies to risk-aversion ones. Risk-taking is rooted in the competency culture, project management, and avoiding an error of commission, while risk-aversion is based on the control culture, systems management, and avoiding an error of omission.

APOLLO AND POST-APOLLO

Apollo Era

Comparing NASA's organizational cultures and public administration practices during Apollo and post-Apollo provides support for the thesis put forward in this chapter that political, technical, and administrative dimensions of large-scale space technology development are interconnected. During Apollo, administrative discretion was counterbalanced by democratic responsiveness. Webb's mission to use science and technology emanating from the space program to strengthen the US economically and educationally epitomizes this. The NASA Administrator sought to create a "Space Age America" based on the "large-scale endeavor" that safeguarded the democratic process.[57] Apollo demonstrated that the US could perform the most difficult and challenging tasks without departing from or damaging the fundamental values of democratic institutions.[58]

"Space Age America" pertained to the NASA-industry-university nexus forged by Webb. Public-private partnerships were established to enable the large-scale technological development needed for Project Apollo. These partnerships provided jobs and skills to diverse areas of the US through the location of NASA field centers and their contractors and subcontractors. It transformed communities in the rural south of the US (Alabama, Mississippi, Texas) to magnets for high-technology industry.[59] Democratic responsiveness was reflected by the fact that it was largely due to congressional pressures that NASA has consistently broadened the geographic and institutional base of its spending and facility location.[60] Educationally, Webb instituted the Sustaining University Program. This program was Webb's primary vehicle for relating NASA to democratic purposes. Webb envisioned the university as a repository of knowledge that could be harnessed to public goals and general societal problem-solving.[51]

During Apollo, NASA's technical culture was predisposed to R&D, incremental testing, in-house technical capabilities, risk-taking, and an exploration ethos. As was discussed in relation to technological innovation, Apollo was largely successful in that it entailed a political response to an emerging set of possible technologies. NASA planners chose and began to implement a lunar landing objective a full two years before President Kennedy announced this choice as a national goal.[62] Foremost, administrative practices during Apollo accounted for institutional, managerial, and technical concerns. The need for a continuing process of adjustment and adaptation to the dynamics of change within and outside the Agency was recognized as an essential part NASA's administrative ethos.

Webb realized that NASA could not be governed by classical principles of public administration that sought to assure stability and order within a rigid hierarchical framework.[63] In order to accommodate large-scale technological systems and allow for technological innovation, public administration remained flexible. The components of the organization, the field centers, headquarters, and the program and project offices, were imposed on a matrix organizational structure. Inputs to this structure involved the complex of in-house management, the corpus of outside contractors, and university supported R&D. Webb had to balance risk-taking and high-reliability management schemes with more traditional public administrative values of order, continuity, and stability. Flexible administrative processes were essential to success as such an entity as NASA could never be expected to become stable and harmonious.[64]

Success was possible because the basic pattern of organization provided for NASA gave it flexibility. Webb used this asset to incorporate maneuverability into NASA's organizational structure; the necessary level of instability, a desired "disequilibrium."[65] This disequilibrium was based on an administrative scheme of simultaneous centralization and decentralization; decentralization allowed for technical competence, and centralization allowed for rigorous controls in systems integration and in cost and scheduling predictions.[66]

One specific way in which organizational disequilibrium was put into place was by imposing an organizational structure on the technical work teams. In relation to the Apollo technical engineering teams, "...engineers needed to coordinate changes among themselves...they aired technical details of changes in coordination meetings. Reorganizing this, managers inserted themselves into these meetings to understand what was happening, and soon required the engineers to give cost and schedule estimates for these changes."[67] An important administrative tool to meet cost controls, in light of the technological development and change, was that of configuration management. This method of management provided an essential link between engineering coordination and organizational control of the technology.

All in all, the establishment, on the part of Webb, of a triad decision-making forum, achieved organizational flexibility.[68] Webb shared top-level decision-making with two associate administrators, Robert C. Seamans and Hugh L. Dryden. Webb served as an institutionalist being responsive to the concerns of the President and Congress; Seamans functioned as an internal bureaucratic manager coordinating the efforts of the field centers through the application of systems management brought into NASA from the US Air Force; and Dryden, former head of NACA, functioned as a technologist based on his background as a highly respected aerospace scientist with a network of connections throughout the technical communities within and outside NASA.

The triad successfully mediated between the political, technical, and administrative dimensions. Webb and Seamans provided the ability for bureaucratic management, management that mediates between the administrative and political dimensions. This ensured both political and organizational accountability. Seamans and Dryden provided technocratic management, management that mediates between the technical and administrative dimensions. This is manifested in the administrative practices and organizational decision-making processes like systems and configuration management.

The breakdown of the Webb-Seamans-Dryden triad, due to the death of Dryden in 1965 and the falling out between Webb and Seamans as a result of Apollo 204, led to the administrative and organizational transition to the post-Apollo era. Webb "was alone, a non-technical man at the helm of a huge technological agency."[69] Consequently, Webb was forced to retain tight centralized control given external politics, which at the time began to shift against NASA, and internal management stresses caused by Apollo 204.[70] Webb began to lose the ability for organizational flexibility and for effective management of the political, technical, and administrative dimensions. This led to an indefinite postponement of post-Apollo program planning and Webb's resignation in 1968.

However, the space age administrative practices that were integrated into NASA allowed for Apollo to succeed and established the basis for how NASA has administered the Space Shuttle and ISS programs. The main characteristics of space age administrative practices encompassed a number of features including: risk management of complex technology through techniques like systems and configuration management, and interface specifications; component redundancies and safety features in technical design; and organizational disequilibrium that allowed for both technical competence and effective managerial control in terms of project oversight and controls on costs, schedule, and reliability.

Post-Apollo Era

In the post Apollo era, a number of factors further upset the equilibrium established by Webb-Seamans-Dryden. The political environment changed and emerged as unfavorable to an Apollo-like space program. This led to an emphasis on political accountability and representation as a means to achieve legitimacy for NASA. Political considerations began to supersede technical and administrative judgments. The practice of producing a democratic consensus to the detriment of

technical considerations, such as reaching political consensus on mission objectives in the case of the Space Shuttle (e.g., one shuttle launch policy) and on design (and continually redesigned) parameters in the case of ISS, has a degrading affect upon the development of large-scale technologies. Further, the political pressures that overshadowed technical considerations promoted risk-aversion reliability.

The response to political accountability led to a fragmentation of authority within NASA. Without a strong centralized public administrative structure, NASA field center autonomy and independence vis-à-vis NASA Headquarters was promoted. The power devolved to the field centers was supported by congressional delegations. This spawned bureaucratization between the centers reinforcing processes of political consensus building on space projects. As a whole, the space program became more captive of congressional interests and the associated factors of ancillary politics and incremental policy-making. The growth, size, cost, and complexity of the technology utilized by NASA reinforced public-private partnerships that resulted in a greatly diminished in-house technical capability and countered reliability systems with notions of utilization (efficiency and operations).[71]

The administrative and management processes utilized during Apollo, such as systems and configuration management, which in various ways are standard operating procedures for the Space Shuttle and ISS, are to an extent incongruous with the more operational oriented tasks of these programs. The space age management techniques were designed for experimental programs like Apollo and were not specifically designed for routine operations in space. Additionally, the unfavorable political climate demanded the rationale of utilization in space, while that same climate was not forthcoming on the budgetary end to make utilization truly possible from a technical standpoint.

NEO-APOLLO ERA?

During the 1990s, NASA Administrator Daniel S. Goldin sought a return to the technical culture that was part of the Apollo era, a "Neo-Apollo" era. The technical culture sought was the team-based approach, which characterized the engineering technical teams that developed Apollo hardware, albeit in the area of planetary robotic exploration rather than human spaceflight. This administrative approach, more commonly known as Faster, Better, Cheaper (FBC), attempted to accomplish both technical competence and organizational control within the team itself. FBC tried to replicate systems management at the team level.

Aspects of FBC were discussed in the chapter on Bureaucracy and the Space Program. The point to make here is that FBC worked when technical

designs could be implemented in the face of political aspects related to costs and schedule, and when the team could informally apply organizational controls. On the other hand, the failed FBC missions, among the most visible being the Mars Climate Orbiter and Mars Polar Lander, were a result of pushing design to costs and design to scheduling too far, and a consequence of insufficient program oversight. The political aspects of costs and scheduling undercut technical competence as manifested in the lack of system redundancy, and inadequate margins and tolerance for technical failures. Most critically, the team failed to replicate the organizational controls characterized by systems management.

CONCLUSIONS

The Presidential Commission that investigated the Challenger accident found NASA's managerial and technical systems inadequate for Space Shuttle operations.

> Pressures developed because of the need to meet institutional commitments which translated into a requirement to launch a certain number of flights per year and to launch them on time...such considerations may have occasionally obscured engineering concerns. Managers may have forgotten...that the Space Shuttle was still in the research and development phase.[72]

The Apollo 204 fire resulted from an imbalance between managerial and technical considerations as well. And, both Challenger and Apollo 204 occurred in part as a result of the nature of the relationship between NASA and its contactors that blocked the flow of technical information to NASA's management. FBC failed because organizational controls were difficult to implement at the project level where technical competence was emphasized.

In all these cases, the three dimensions, political, technical, and administrative, contributed in various ways to the failures. Most compelling is the finding that these three dimensions are causally linked. The three dimensions play a role not in isolation of each other, but as an interconnected set of factors that produce public administrative outcomes. Changes in any one dimension can produce changes elsewhere. Of equal merit is the insight that a balance among all three dimensions has led to greater chances of public administration success in the process of implementation.

The public administration of the space program is ultimately linked to the balance achieved among the three dimensions. If administrative practices

can successfully account for organizational and external institutional concerns, then technical considerations can guide the development and operations of space technology. In the final sum, the R&D and operations of large-scale technology depends on the skill to which the organization administering that technology can adapt to changing circumstances internally and externally.

At issue is the effective promotion of the technical considerations and competence that are of paramount importance in implementation success. Administrative practices that strike a harmonious relationship among political, technical, and organizational factors provide centripetal forces to the centrifugal pressures outside the agency that work to mollify the capabilities of high-reliability organizations. For NASA and the US space program, its future in the twenty-first century, a human-tended lunar base and human missions to Mars, depends on such public administrative skill.

PART THREE

SPACE POLICY OUTCOMES

8
SPACE AND THE ENVIRONMENT

Eligar Sadeh*
James P. Lester (1945-2000)†

> "Now is the time to take longer strides, time for a great new...enterprise, time...to take a clearly leading role in space achievement, which in many ways may hold the key to our future on Earth."
>
> *President John F. Kennedy*

INTRODUCTION

In his address to the United States (US) Congress on 25 May 1961, this quote by President Kennedy indicates recognition of the potential that space could provide for a better understanding of the Earth's environment. The late Professor Carl Sagan has remarked that space exploration is important for nothing less than "species survival."[1] Sagan suggested that space exploration, and ultimately settlement, was important as an "insurance policy" against environmental despoliation of Earth. This suggests that new options, ones that allow for humanity to migrate and settle on other planetary bodies like the Moon and Mars, be feasible so that humanity could survive terrestrial environmental crises such as global climatic change or the possibility of impact with a Near Earth Object (NEO).[2] The observations by Kennedy and Sagan, among other writings reviewed in this chapter, suggest inextricable links between space and the environment.

Beginning in the 1960s, a number of NASA initiatives have developed a linkage between the study of space and the environment. Among the more recent initiatives are NASA's Earth Science Enterprise, Earth Observing Satellite (EOS) program, Orbital Debris Office,[3] NEO Program Office, and the Astrobiology program. There are a number of political, economic, and philosophical concerns that arise over the relationship between space and the environment. Some of these concerns include global warming, remote sensing data policy, and the ethical issues associated with space

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exploration. This chapter addresses these concerns by first highlighting the evolution of environmental policy to establish the historical context for a discussion of space and the environment, and then by assessing the various dimensions, the pertinent policy and ethical issues, of the relationships between space and the environment.

EVOLUTION OF ENVIRONMENTAL POLICY

Several observations can be drawn from an examination of the evolution of environmental policy as it has taken place in the US.[4] This evolution is summarized in Table 8.1. First, the environmental movement has steadily broadened its base of support. It has moved from being largely an elitist concern, scientific and government experts as environmental policy-makers, to one with support throughout society. This movement is reflected in the literature, which suggests that "advocacy coalitions," composed of interests from national governments, private sector, and nongovernmental organizations (e.g., grass-root environmental groups), are now involved in environmental policy-making.

Table 8.1. Evolution of Environmental Politics and Policy.

	1890-1960	1960-1990	1990-present
Scope of Issues	1st Generation Preservation/ Conservation	2nd Generation Local/Regional	3rd Generation Global/ Transboundary
Policy	Resource Use	Pollution Prevention	Global Change
Participation	Elites	Elites	Advocacy Coalitions
Concern	Environmental Science	Economics/ Politics	Philosophy/ Ethics

Second, and more applicable to the focus of this chapter, are the changes in how the severity of environmental problems is evaluated. As a whole, there has been an evolution from a primary concern over "natural resource issues" to "environmental issues." This change has evolved from first-generation problems concerning resource preservation and conservation (e.g., public lands, water rights, park management), to second-generation problems involving pollution prevention aimed at "clean air" and "clean water" (e.g., toxic waste, groundwater protection), and to third-generation

problems dealing with global change (e.g., global warming, biological diversity, thinning of the ozone layer, deforestation).

The environmental movement in the present "third-generation" era can be characterized by the breadth of its constituency, type of issues that are viewed as important, approaches taken to deal with environmental problems, and emphasis on philosophy and environmental ethics.[5] Scholars are concerned with philosophical perspectives that deal with political ideas, values, ideologies, and principles of governance. Given these concerns, one important focus of third-generation problems is the issue of how environmental ethics or ideologies might change political decision-making. It is these dimensions, the concern about third-generation environmental problems and policy ethics, which are applied to assess extraterrestrial environmental issues.

THIRD-GENERATION ENVIRONMENTAL PROBLEMS

Anthropogenic alteration of the Earth's biosphere has contributed to an environmental problematic. This problematic is demarcated by concern about global commons and a collective action problem. Commons are commonly held physical or biological resource domains that lie outside the jurisdiction of any individual country. These resources are in joint supply and nationally non-appropriable. Joint supply denotes equal potential availability to commons by all states. Non-appropriability indicates that it is impossible to exclude states from sharing in benefits of commons resources or from suffering consequences caused by damage to them. As a result, any user may exploit commons resources since exclusion is impractical. This explains why global environmental degradation is so difficult to prevent or reverse. Earth observations by satellite (e.g., EOS), for example, concern commons resources affecting global environmental change.[6]

A collective action problem results from a "tragedy of the commons."[7] This tragedy is rooted in self-interested behavior in relation to commons resources. A "tragedy" occurs when the value of commons resources diminishes as a result of exploitation. This reflects a complex and dynamic problem set that sits at the juncture of politics, science, and technology.[8] An important political challenge, as it relates to realize missions for Earth observations by satellite, is to bring about international collaboration in the creation, production, and dissemination of knowledge, Earth remote sensed data, about global environmental change. Coping with and adapting to global change depends upon science and technology. Political actors cannot exercise control over environmental problems without recourse to scientific

findings. Science relies on technology (e.g., Earth remote sensing satellites) for assessing environmental degradation.

National Level

At the national level within the US, scientific awareness about global change led to formulation of the US Global Change Research Program (USGCRP) in 1990. The goal of USGCRP is to "provide for the development and coordination of a comprehensive and integrated United States research program, which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change."[9]

This program is cognizant that scientific knowledge is crucial to informed decision-making on environmental issues related to management of commons resources.[10] The primary component of USGCRP is NASA's Earth Science Enterprise. This enterprise involves a constellation of Earth observing satellites, including EOS, to assess global environmental change and to distinguish between natural change and human-induced change.

International Level

At the international level, the primary type of remote sensing systems contributing to the acquisition of data for global change research are the specialized and technologically advanced research satellites known collectively as Earth observation satellites. Coordination of efforts among the countries involved with Earth observation satellites has taken place through the Committee on Earth Observation Satellites (CEOS).[11]

The space-based remote sensing policy milieu in some respects inhibits the use of remote sensing data for public service oriented environmental research such as advocated and coordinated by CEOS. While the potential of Earth observations to contribute to the understanding and management of the Earth's ecosystem is high, there are potentially incompatible or conflicting policies regarding the management, supply, and exchange of data. A data policy acceptable both to the suppliers and the wide range of users, scientific and others, of data is required if CEOS is to work.

An additional issue of concern, as it relates to space and the environment, is the political tension in Earth observations between developed and developing countries. These political tensions, in their more radical form, translate as a form of "eco-imperialism." From this vantage point, the developed world is seen as using the environmental problematic as an excuse

to prevent the developing world from realizing their economic development and modernization goals.

EXTRATERRESTRIAL ENVIRONMENTAL PROBLEMS AND ETHICS

Some of the space development and exploration goals for the twenty-first century are to: establish a permanent human presence and infrastructure in orbit around Earth (e.g., International Space Station program); develop space commerce by capitalizing on the use of the natural resources that space has to offer; establish a human-tended lunar base; launch human missions to Mars and eventually settle Mars; and explore the Solar System and cosmos for evidence of extraterrestrial indigenous life forms.

An important objective for NASA, other governmental space agencies, and the space commercial sector in meeting these goals is to spread life in a responsible fashion throughout the Solar System. Such a responsibility justifies that policies and plans be guided by environmental and ethical considerations. A failure to take these considerations into account could lead to a scenario whereby exploratory and commercial projects for space produce a new extraterrestrial environmental crisis that dwarfs the current one on Earth.[12]

Ethics, as a distinctive feature of humans to reflect and question the justification, motivation, contents, significance, and repercussions of their actions, is particularly necessary in the space field now that space has become accessible to human beings.[13] Ethical questions condition the acceptability of policies and plans in space. "Space ethics" raise increasingly important questions that include a concern for the extraterrestrial environment. Important questions to consider include: what is the role of human beings in the cosmos; how can links between Earth and space be organized; who is to determine the priorities and choices of science and on the basis of which objectives to society; and what is the level of moral responsibility to which individuals, groups, organizations, and governments must aspire for present and future generations.

One possible way of ascertaining the evolution of environmental ethics is illustrated in Figure 8.1. This evolution transpires in such a way that there is a continuous evolving system of ethics in which an extension in concepts of justice beyond humans is applied to all animals, then to plants, then to entire ecosystems, then to the Earth as a whole, and finally to the entire cosmos. In this regard, three distinct dimensions are identified: anthropocentric, biocentric, and cosmocentric. These three dimensions can serve as a roadmap for formulating space policy on the basis of environmental

and ethical considerations; how can environmental ethics (and those ethical frameworks still to be developed) be used to prevent an environmental disaster in the cosmos?[14]

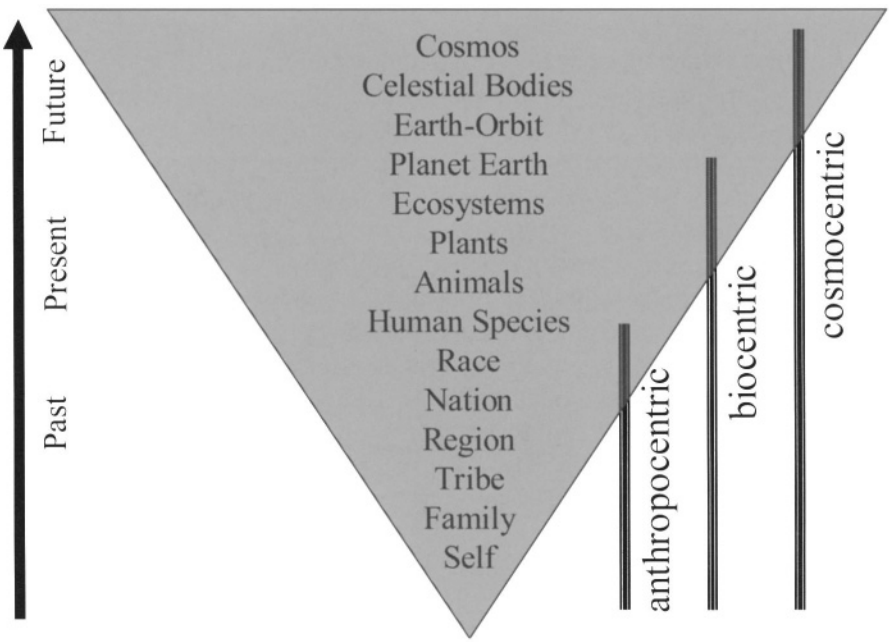

Figure 8.1. Evolution of Environmental Ethics.

Anthropocentric Dimension

In the anthropocentric dimension, humans are treated as ends in-and-of-themselves and act as moral agents in relation to the environment. Nature is of instrumental value in that it contributes to human life. Anthropocentrism is rooted to the "principle of nature as a utility for human ends." In this vein, the environment can be both exploited and protected to safeguard and further human interests and the persistence of human civilization. The "exploitation-of-nature" argument states that it is permissible to exploit the environment when it enhances human well-being. This view would establish policies for humans to extract resources from space and planetary bodies, create human-supported biospheres in space and on planetary surfaces, and terraform celestial bodies. This particular ethic sees the bounty of nature (on Earth or in space) to use in a wise and constrained manner, but the measure of value is ultimately tied to the

present and future needs of humans.

It is humanity that counts. If Mars, for instance, counts more to humanity as a second home than as a barren desert (with possible living microbes), then living there and terraforming the planet would be a moral cause.[15] This implies that terraforming Mars would take precedence over preserving any indigenous life forms that may be found there. In other words, "bacteria don't have rights, the idea of denying humanity a new world such as Mars to provide a reservation for extraterrestrial bacteria is ludicrous."[16]

The "protection-of-nature" argument states that the environment should be protected not because it has rights or an intrinsic value of its own but to safeguard human ends. With this argument the focus is on human concerns that evade the intrinsic value of natural environments. Environmental protection of some sort may be promoted, but instrumental ends such as science, economics, and aesthetics are the drivers for this protection.

Hence, policies that protect bacteria on Mars may be needed because bacteria may have an instrumental value to the human endeavor of science.[17] International space law has designated space and celestial bodies as "commons" resources, a collectively-held good to be protected for human ends or uses. This approach could engender policies that aim to: prevent the contamination of planets hospitable to life forms for scientific inquiry; conserve natural resources in space for economic development purposes; and preserve aesthetics of planetary surfaces (or even interplanetary space) for human enjoyment.

Science and Contamination

Of particular interest to NASA and its Astrobiology program is the policy issue of science and contamination. The Astrobiology program is studying the origin and evolution of life, and life-related processes and materials throughout the Solar System and cosmos. Such profound questions as how, why, where, and when did life begin, and how did the Solar System and its objects form, evolve, and (in the case of our own planet) produce an environment that could give rise to and sustain life are being explored. The relationship between the origin and evolution of life, and the origin and evolution of the Solar System is not well understood, but it is known that life is intimately connected with its environment.

The discovery of this connection depends upon the extent to which humans can prevent the contamination of any evidence. Contamination issues of concern include: to what extent will there be contaminant leakage and

harmful effects to indigenous life forms; to what extent will contamination mask the existence of indigenous life forms; will contamination due to humans be local or global; what are the criteria for obtaining biological status of a planetary body; and what are the guidelines for in-situ activities to keep potential environmental impacts to a minimum?

NASA has begun to address some of these issues by establishing a Planetary Protection Office and instituting policy guidelines regarding planetary protection.[18] These guidelines incorporate both "forward" and "backward" contamination issues. "Forward" contamination seeks to prevent Earth organisms from contaminating another celestial body. The procedures for accomplishing this include the pre-launch sterilization of spacecraft parts that will come into contact with the surface of the planet, the installation on a spacecraft of a bioshield for launch and reentry, and the in-situ handling and preservation of any sample recovery in an unsterilized form. Of equal concern is that of possible "backward" contamination (e.g., contamination forthcoming from another planet to Earth). The current NASA guidelines call for a sterilized and preserved transfer of a foreign terrestrial sample to be held at a containment facility here on Earth.

Recently, NASA's planetary protection policies were put into practice and impinged on the way a spacecraft mission is conducted. At NASA's request an independent team of experts, the Space Studies Board's Committee on Planetary and Lunar Exploration (COMPLEX) of the National Research Council, considered policy options for planetary protection of Europa. One issue before COMPLEX was to recommend to NASA on the disposal of the Galileo spacecraft without harming the possible life forms that scientists believe might exist on Europa.[19] COMPLEX saw serious planetary protection issues (i.e., forward contamination) as a result of the intentional or unintentional disposal of Galileo on Europa. As a result, COMPLEX concurred with NASA's suggestion that Galileo should be navigated to impact Jupiter.[20] The main driver for this recommendation is based on human ends, to protect the scientific validity of future experiments on Europa.

NASA's planetary protection provisions are represented on the international stage through the mediation of the International Council of Scientific Unions' Committee on Space Research (COSPAR). US representatives have taken a leading role in the formulation of COSPAR planetary protection policies that are directed at fulfilling the provisions of the 1967 Outer Space Treaty to avoid the harmful contamination of the Moon and other celestial bodies.[21] These policies have closely mirrored NASA's policies as summarized above. In fact, NASA's current planetary protection policy document stipulates that NASA will not participate in international missions unless each international partner agrees to follow COSPAR's planetary protection policies.

Moreover, COSPAR has formed a panel on planetary protection that is concerned with the development, maintenance, and promulgation of planetary protection knowledge, policy, and plans to prevent the harmful effects of biological contamination on celestial bodies.[22] For possible future missions, such as Mars sample return, Europa orbiter and lander, and other missions to small bodies of the Solar System (e.g., asteroids, moons), an international consensus agreement on planetary protection will be an issue.

Biocentric Dimension

The biocentric dimension is based on maximizing the well-being of the totality of living existence. With this approach, value is assigned to all of living biology. Thus, humanity has a direct obligation to the welfare of that biology. By way of illustration, the need to maintain and value extraterrestrial indigenous life forms would take precedence over the right of life from Earth to exploit and destroy those life forms. This ethic is rooted in the "principle of the value of life." Humans have a responsibility to respect and support the interests of life whether animal, biota, or microbes.

As applied to space exploration, two biocentric worldviews can be identified. One view deals with enhancing the survival of any indigenous life forms (Martian or other) and promoting global change (on Mars or elsewhere) that will allow for maximizing the richness and diversity of those life forms.[23] Put more succinctly, this view would entail the "planetary engineering" (terraforming) of Mars to allow for Martian life to proliferate and then quarantine the planet for environmental protection. This is akin to stating that the survival needs of humans outweigh the survival needs of non-humans, but the survival needs of non-humans outweigh the non-survival needs of humans.[24]

> ...there is an issue of moral consideration to indigenous Martian life. In the approach to terraforming that I am proposing, Martian life has rights. It has the right to continue its existence even if its extinction would benefit the biota of Earth... First and foremost is a requirement that the rights of any indigenous biota life be respected.[25]

A second view advocates "environmental responsibility" to the entirety of life. If a world is inhabited (even if only by microbes), do humans have a moral right to alter it? Further, are humans responsible to preserve the worlds of the Solar System in their present wilderness states for present and

future generations? Advocates of terraforming to preserve indigenous life forms must first become advocates of long-term and thorough scientific exploration of other worlds.[26] Inherent in this take on biocentrism is the idea of a "rights" based view that supercedes any human right to terraform (or alter by other means) the extraterrestrial environment. "If there is life on Mars...we should do nothing... Mars then belongs to the Martians, even if they are only microbes."[27]

Cosmocentric Dimension

A cosmocentric ethic has been characterized as one that establishes the cosmos as a priority in a value system.[28] An intrinsic value permeates all levels of both ecological and geomorphologic hierarchies; all "named" features and those to be discovered have an inherent right to exist. This ethic is rooted in the "principle of the sanctity of existence." Moral behavior under such a system would involve non-violation of the extraterrestrial environment and the preservation of its existing state whether that state is biological, ecological, or geomorphological.[29] On a more practical level, a cosmocentric ethic implies that environmental and ethical considerations directly inform the planning for the exploration and development of the Solar System.

CONCLUSIONS: ENVIRONMENTAL ETHICS OF SPACE POLICY

Future policies for space exploration, including the possible discovery and physical interaction with extraterrestrial life, will need to account for the extent to which anthropocentrism is inevitable. The case for anthropocentric inevitability contends that human activities in space are unavoidable since they are consistent with the dominant myths and metaphors of Western Civilization.[30] This implies that there is a link between the culture that engages in space exploration and anthropocentrism. If a lack of concern for the biological, ecological, and geomorphological features of the cosmos is part of the dominant culture and exploratory pursuits, then perhaps a fundamental reorientation of Western culture is in order.[31]

The further the ethical framework departs from anthropocentrism (i.e., to biocentrism and cosmocentrism) the greater is the moral constraint on human freedom of action within the space environment.[32] Since ethical morality regulates behavior, it is important to consider what the fundamental policy choices are. One approach suggests that possible policies should be formulated according to their scientific value.[33] This implies the protection of selected sites (e.g., celestial bodies and interplanetary space) for scientific

study and astronomical observation. The sites selected for environmental protection would be undertaken with regard to their scientific value and uniqueness.

To an extent, this approach is reflected in NASA's and COSPAR's planetary protection policies:

> For much of the history of the implementation of planetary protection regulations, the protection of future scientific experiments has been assigned the most weight in determining planetary protection requirements. Indeed, planetary protection policies have centered on the concept of a period of biological exploration, during which particular planetary bodies are accorded protection from contamination so that studies of their biological potential can proceed unhindered by terrestrial contamination.[34]

In this chapter, three ethical choices were identified and discussed. These choices are summarized in Table 8.2 along with the probable polices each ethical framework advocates. Ethics can help to determine policies. The policies that are established will determine if the choice is made to: alter the extraterrestrial environment; assist in preserving and protecting the extraterrestrial environment; or peacefully co-exist. Ultimately, what humans do with the extraterrestrial environment depends on its value as an object of scientific inquiry or enjoyment compared with the intrinsic value of the world in question opened up for possible human study and settlement.

Table 8.2. Ethical Frameworks of Space Policy.

Ethical Frameworks	Central Moral Principles	Probable Space Policies
Anthropocentrism	Nature as a utility for human ends.	Human ends for settlement, science, and enjoyment.
Biocentrism	Intrinsic value of life.	Protect and preserve biological features.
Cosmocentrism	Sanctity of existence for cosmos.	Protect and preserve biological, ecological, and geomorphological features.

Technological change, social forces, economic development, and ethical values affect the policies of space and the environment. The intelligence with which policies are made can be improved by a better understanding of these factors, and the major issues related to space and the environment that have been addressed in this chapter.

9
SPACE LAW

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INTRODUCTION

The corpus of international space law emerged as a discipline of jurisprudence after the 1957 Soviet launch of the Sputnik satellite. This "shot heard around the world" marked a major escalation in the Cold War for both the United States (US) and the rest of the Free World. Only then did the legal and political implications of outer space become fully evident to politicians and lawyers alike. The history of international space law, therefore, cannot be understood apart from its origins in the Cold War. Indeed, the development of the international law of outer space is inextricably linked to this context of international politics and policy.

This chapter covers the evolution of space law from its origins to the present day. A major theme in this evolution has been the transformation of space law from its original pro-state, military, and governmental emphases into a legal regime that accommodates and encourages private, commercial, transnational, and multinational activities in space.

LITERATURE AND ISSUES

Space law can be viewed as a case study of how policy is made and then formulated into law. This law then becomes a factor in policy decision-making for governments, businesses, and individuals involved in space activities and commerce. Since the launch of Sputnik, there have been numerous review articles and books written on space law representing the views of many nations and ideologies in the world.

Until recently, the evolution of international space law was almost exclusively a by-product of the struggle between capitalism and communism, and the rise and fall of the Cold War. In addition, space law reflected the broader ideological struggle between the developed and developing worlds. These debates, which included liability for space accidents, and ownership of the Moon and its natural resources, were path-breaking not only for space law

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scenarios, but also as legal analogies for regimes dealing with the land and sea here on Earth.

Some of the major sources for the English language literature in space law include: the proceedings of the International Institute of Space Law (IISL) from the annual meeting of the IISL held as part of the International Astronautical Federation (IAF) Congress; the *Annals of Air and Space Law,* the law journal of McGill University, which is a recognized and respected forum for space law in English and French; and the *Journal of Space Law,* published through the Law School of the University of Mississippi, which represents one of the most authoritative, comprehensive centers for space law. Other space law literature may be found in journals that emphasize international or comparative law. Moreover, the rise of commercial space activities as well as the distribution of space law articles into wider, mainstream municipal law journals reflects the rise of a private commercial law of outer space. This trend reflects the arrival of space activities as an integral and substantial part of Earth-based commercial affairs.

EVOLUTION OF SPACE LAW

The evolution of space law can be arranged according to three-eras encompassing the classical period (1957 to 1979), transitional period (1980 to 1991), and modern period (1992 to the present).[1] This approach focuses on changing political and technological realities as a basis for understanding the evolution of the laws governing activities in outer space.

In the classical period, the major documents and the basic structure of international space law were conceived. The defining characteristics or variables that informed the law of that period were the Cold War, and the nature of space activities and national space programs that were dominated by military and foreign affairs. As a result, classical international space law reflects a pro-state, anti-free enterprise orientation.

During the transitional period, space became important to many more states and thus, world political forums, such as the United Nations (UN), became increasingly unable to reach agreement on the rules that would govern space activities. This was exacerbated by the fact that space activities became more diverse with commercial applications. In this period, public international space law entered a hiatus. In its stead, domestic space law and private international law (contractual negotiations among states and corporations) expanded to fill the legal void.

The modern period continues to see the increasing sophistication of technology and markets for space commerce. Coupled with the demise of the Soviet Union, with its commitment to state domination, the law of outer

space, international and domestic, has begun to reorient more towards the commercial development of space. The hiatus in international space law, noted in the transitional period, has given way to a new productivity, albeit so far only in providing declarative and symbolic statements rather than codified treaty law.

The evolution of space law as it has developed over the course of the space age is informed by these three-eras. Herein, the focus is on public international law, domestic space law, and the emergence of private international space law.

Classical Period

International space law, like all the other branches of international law, has two sources: oral or customary law, and written or treaty law. The best example of customary space law goes back to the origins of space exploration and to the question of where does outer space begin. This question has no answer in treaty law; yet, an answer is important because air and space have two very different regimes of law: national sovereignty is the norm for aviation, and free access and non-appropriation is the rule for outer space. When Sputnik orbited over many national borders, no state complained or claimed an invasion of sovereignty. When twenty years later, several equatorial nations raised the issue and claimed sovereignty over the geosynchronous orbits, their claims were not accepted; this rule of law simply had already been established by practice and custom.

The exact physical measure of where outer space begins remains one of the fundamental, but unresolved issues in all of space law. Some scholars and nations have argued for a spatial definition of delimitation (although they have often disagreed on the appropriate altitude). Others have advocated a functional definition or, at least, a hybrid of the two approaches. Although still somewhat unsettled and debated in various international bodies, the generally accepted definition of where space begins is a hybrid one-predominantly spatial (about 60 miles, 100 kilometers), but with a functional component (such as for a spacecraft not yet in orbit). This is the customary rule, but the states of the world continue to debate it and to raise the question whether a clear written or treaty rule is needed.[2]

Most of international space law is indeed treaty law; the national and international actors in space need the clarity that can only be provided by written rules. In response to Sputnik and the issues raised by space activities, the UN became the focus of space law development. The UN was able to

move quickly into the political and legal vacuum of space and play a major role in developing a legal regime for outer space.

In 1958, the UN created the Committee for the Peaceful Uses of Outer Space (UNCOPUOS). This body, composed of initially eighteen states, began discussions and negotiations on the issues of space law. The Committee has since grown to more than sixty national members. Realizing the importance that its decisions would have, UNCOPUOS initiated consensus decision-making. In other words, if no one objects to the legal provision that is proposed, it is accepted; however, nations are only bound by the interpretation that they place on the provisions. The custom evolved, therefore, to draft the treaties ambiguously so that they are more easily agreed to based on the various national interpretations given to the legal provisions. Once consensus is achieved, the resulting document is submitted to the UN General Assembly for its approval.[3]

The resulting UNCOPUOS treaties establish the core regime of international space law. Legal agreements pertaining to other international organizations, such as the International Telecommunications Union (ITU) Constitution and Convention, the Agreement Relating to the International Telecommunications Satellite Organization (Intelsat), the Convention for the Establishment of the European Space Agency (ESA), and the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, make up most of the remainder of public international space law.

The first UNCOPUOS treaty established the basis for international space law. This 1967 "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies" (Outer Space Treaty) has been ratified by ninety-six states, with an additional twenty-seven having signed it, as of February 2001.[4] The most fundamental provision of the Outer Space Treaty deals with the political nature of outer space: space is "the province of all mankind;" it is solely "for peaceful purposes," and is for "the benefit and in the interest of all countries." This treaty forbids "national appropriation by claim of sovereignty...or by any other means" of outer space, the Moon, and other celestial bodies.[5]

Another important provision makes nations responsible and liable for the activities of their nationals in space. This legal provision, which puts forward strict liability for damages on Earth caused by space objects, encourages nations to closely regulate the activities of their nationals in space including nongovernmental entities (commercial, private corporations).[6] Even though the US and its allies were committed to free enterprise while the Communists were opposed, the liability provision was the result of a fundamental compromise between the two political camps that legitimated a nationally regulated status for space commerce. One fundamental question for space law today is whether national regulation is appropriate given the

political and economic realities involving multinational and transnational space activities in the commercial sector.

Similarly, the Outer Space Treaty reached important compromises between the West and East on the status of the military in space. The Moon and other celestial bodies are solely for peaceful purposes; no military installations are permitted whatsoever (although military personnel are permitted). Further, the treaty bans nuclear weapons and weapons of mass destruction from outer space in essence crating a de-militarized zone in outer space.[7] However, reconnaissance satellites and weapons that are neither nuclear nor ones of mass destruction (e.g., anti-satellite weapons) have been viewed to be permitted under international space law.

Other provisions in the Outer Space Treaty concern the return and rescue of astronauts and the protection of the environment both in space and on Earth. Article 5 of the Outer Space Treaty proclaimed astronauts the "envoys of mankind." Not only are astronauts due every respect, but practically, if an astronaut were to crash land in another nation, that nation would be required to return him or her immediately and to render all other necessary assistance. The protection of the Earth deals with the issue of "backward contamination" possibly caused by objects brought back from space and with the prohibition on environmental modification of outer space. Settling another important question of jurisprudence, the Outer Space Treaty also makes outer space subject to the international law of Earth, including the UN Charter. Whatever its eventual parameters, outer space activities have to be administered under the rule of international law and for peaceful purposes.

Regime of International Space Law

There are a number of related treaties that make-up the regime of international space law including the "Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space" (Rescue Agreement), the "Convention on International Liability for Damage Caused by Space Objects" (Liability Convention), and the "Convention on Registration of Objects Launched into Outer Space" (Registration Convention).

The Rescue Agreement reveals the obsolete nature of classical space law. This agreement provides for the rescue and return of astronauts and space objects located anywhere, in areas under national sovereignty, and in areas beyond national control (on land or sea, in air, or outer space).[8] It builds on the provision in the Outer Space Treaty that declared astronauts the envoys of mankind. The treaties (Rescue Agreement and Outer Space Treaty) reflect

the technology of the 1960s calling for the best efforts of a nation to assist in any rescue operation. At the end of the 1990s, with two systems that could fly rescue missions (US Space Shuttle and Russian Soyuz) and the multinational International Space Station (ISS), it would seem that these treaties need to be reopened in order to consider new rules for competency. For instance, the treaties do not discuss liability or responsibility for a botched rescue. Also, should a "Good Samaritan" provision be added in order to protect whomever the rescuers to further encourage such attempts?

The Liability Convention reflects most clearly an anti-private enterprise, pro-state bias of the first era of space law. This Convention establishes a strict liability standard for any damage on the Earth caused by space objects without limit on damages and without regard to fault, going well beyond its nearest analogy in aviation law.[9] It mandates a process for settling international disputes in space. After exhausting the diplomatic channels, one nation can bring a complaint for its nationals or other specified persons against another nation. First, the treaty dictates the establishment of a commission to handle the dispute. Second, the plaintiff nation or nations appoint(s) one member; the defendant nation(s) appoint(s) a second. Third, the two members then select a third member as its chairperson. If the defendant does not pick its member or (if more than one nation) cannot agree on a member, the UN will select one member to serve as a one-person commission.[10] Although this process seems very formal and stable, the Convention, in fact, reveals the underlying weaknesses in much of international space law. The elaborate procedure results in a written, published ruling, however, unless the parties agree beforehand, the decision is not binding. Needless to say, in more than a quarter of century, no commission has been formed.

Lastly, the Registration Convention authorized the standard for establishing jurisdiction over objects in space. This Convention required the nation that would assume control, jurisdiction, and responsibility for its space object to register the launch and spacecraft with the UN registry.[11] Although the treaty calls for a detailed report including orbital parameters and the purpose of the flight, there is no policing of the accuracy of that report. Most telling, no nation has ever registered a satellite launch as having a military purpose. The Registration Convention was the last treaty to be widely assented to and to become part of international treaty law of outer space.

Transitional Period

By the end of the 1970s, changes were occurring in space technology and activities that would have a direct impact on space law. More states were

becoming involved in space. Furthermore, the emphasis in space activity was shifting from civil to the commercial sector, the best examples being telecommunications and remote sensing satellites, and related launch vehicle industries. These shifts led to a changing focus in space law and, as a result, it became increasingly difficult to obtain agreement or consensus on issues in public international space law.

Negotiated throughout the 1970s, in that era's political context where third world developing states became a majority in the UN system, the 1979 "Agreement Governing the Activities of States on the Moon and Other Celestial Bodies" (Moon Agreement) was the last treaty agreement to be approved by consensus in UNCOPUOS. Despite this legal approval, the Moon Agreement has been ratified in the ensuing twenty plus years by only a handful of nations,[12] among them no major space powers, and, thus, has never become a part of the accepted body of international space law.

That treaty, as drafted, repeated many provisions of the Outer Space Treaty, but it added sections dealing with the rights of ownership in mining and other uses of the Moon and other celestial bodies. Proclaiming that the resources of the Moon "in place" are the common heritage of mankind, this treaty calls for the adoption of an "international regime" that would equitably administer or otherwise manage the use and allocation of lunar and other space resources.[13]

In order to obtain consensus, the US emphasized its interpretation that would have permitted the on-going commercial development of space: once the resources were "out-of-place" (mined or extracted) as opposed to "in-place" then ownership could be applied; the international regime contemplated could be one that permitted commercial development of space resources whatever its regulatory framework; mining could begin immediately; and the treaty did not impose any interim moratorium on development of space resources. Albeit the US interpretations were at odds with those of many other nations, under UNCOPUOS procedures, the US is bound only by its interpretation of the treaty. This legal stratagem permitted UNCOPUOS consensus, but suggests an unworkable legal regime. The US Senate refused to ratify the Moon Agreement even subject to these US interpretations.

In the transitional period, UNCOPUOS debated many important issues, resolutions, and treaties to advance the overall framework of space law, but it has not been the source of new treaty law. UNCOPUOS began to craft a new role for itself, turning a vice into a virtue. In other words, if UNCOPUOS could not develop new treaty law, it would at least offer norms and guidelines for space law. The "Principles Relating to Remote Sensing of the Earth from Outer Space" adopted by the UN General Assembly in 1986 is

a case in point. Since 1974, UNCOPUOS could not get consensus on a remote sensing treaty because of divergent views concerning national sovereignty and prior consent from the nation to be "remotely" sensed. As such, UNCOPUOS dropped its effort to produce a treaty and opted for consensus on a resolution to be submitted to the UN General Assembly. Thus, UNCOPUOS put aside its role as law-maker, and opted for a new role as norm setter for space activities.[14]

In 1986, the nations of UNCOPUOS struck a compromise that would be a harbinger of the future direction of public international space law in relation to remote sensing. Developing nations dropped their insistence on prior consent when the spacefaring nations agreed to a norm of international cooperation based on "equitable and mutually acceptable terms."[15] This translated in the legal norm that when one state acquires data over another, the remotely sensed state should have access to the data on a non-discriminatory basis and on reasonable costs terms; this is usually interpreted to mean just the cost of disseminating the data. It is this norm that informed and justified US domestic law regarding Landsat, and data policies regarding Earth observations as advocated by the Committee on Earth Observation Satellites (CEOS).

As international space law entered this hiatus, domestic space law and private international space law became important. To illustrate, the US had been the first nation to fully develop commercial applications of space involving telecommunications. The US Federal Communications Commission (FCC) has nurtured the industry, and, in the process, created a new area of law. In addition to other activities, the FCC licenses companies to launch and operate domestic telecommunications satellite. Similarly, the Office of the Associate Administrator for Commercial Space Transportation (known previously as the Office of Commercial Space Transportation) within the Federal Aviation Administration (FAA) licenses launch vehicles and launch sites generating a new regulatory regime for space commerce. A similar mechanism for licensing and regulating commercial remote sensing satellites has been entrusted to the Office of Space Commercialization in the Department of Commerce.

As space applications have spread around the world, corporations created and competed for space goods and services. The result has been the creation of private international space law.[16] This law is rooted in transnational contracts that create actual procedures and practices to handle liability, responsibility, and dispute resolution (conflict of laws) among aerospace companies. At the same time, more states have had time to consider the need for a national body of law to regulate and otherwise facilitate space development. Even though the US was the first to develop law for space regulation, other countries have followed suit. The economic

reality of space applications is creating not only new commercial endeavors in space, but also commercial space law.

Modern Period

The modern period can be characterized by a renewal of international space law. Unable to reach consensus on further treaties, UNCOPUOS has forged a new role for itself. It has been the source of four major resolutions: one on nuclear power sources in space,[17] one on direct television broadcasting,[18] one on remote sensing,[19] and another resolution on sharing the benefits of space.[20] Additionally, it has been the major forum for discussions on space debris and other important issues. UNCOPUOS also is the body that called for the Third Unispace Conference (UNISPACE III), which represented most of the national and international space interests throughout the world. The political source for this renewal in public international space law is the demise of the Communist Empire, and the adoption of free market and free enterprise economic models.

This trend in space law is most evident in the telecommunications field. Realities, such as international economies of scale and permeability of borders, have dictated new international commerce and international legal regimes. One aspect of this change was the negotiations in the ITU at the 1992 World Administrative Radio Conference (WARC). In negotiations over high-definition television (HDTV), mobile phones, and small satellites, the US, Russia, and most of the developing world backed a deregulation of small satellites in opposition to the position of the European Bloc. Indeed, one observer found this "...the first ITU conference in which the developing countries played a critical, decisive role in favor of implementing new technology."[21]

The creation of the World Trade Organization (WTO) marks the new high water mark for this trend by committing WTO members to a liberalization and deregulation of communications markets. Even most of the European and Latin American countries, such as Mexico, Venezuela, Peru, and Chile, have agreed to open or loosen up their closed markets to foreign competition. Further, an ad-hoc group of forty nations, from developed and developing, spacefaring and non-space powers, was created in 1996 as a forum to address the relaxation of regulatory hurdles to cross-national business.[22]

Today, much of space commerce is characterized by multinational strategic alliances. This has raised a slew of legal questions regarding jurisdiction and liability. One good example of this is Sea Launch. This

commercial endeavor launches from international waters, which are defined as a commons by the Law of the Seas, on a platform built by a Norwegian company, with a Russian company's Zenit rocket, where Boeing of the US provides the systems engineering integration expertise and know-how.

THE FUTURE OF SPACE LAW

United Nations Resolution Case

A recent and important example of international cooperation at the diplomatic level is the UN sponsored 1997 resolution, "Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries." The documents language is, as usual for these international agreements, general and ambiguous to reach consensus in UNCOPUOS. Nonetheless, legal scholars have called this document as symbolic of the end of the North-South debate on space law. In many ways, this resolution represents the US perspective on the relevant treaty language as modified by two decades of compromise with developing countries.

The specific "common heritage of mankind" language that so bedeviled the Moon and the Law of the Sea debates is quite noticeable in its complete absence from this resolution. In the recitations located at the beginning of the resolution, the preamble states:

> *Recognizing* the growing scope and significance of international cooperation among States and between States and international organizations in the exploration and use of outer space for peaceful purposes,
>
> *Considering* experiences gained in international cooperative ventures,
>
> *Convinced* of the necessity and the significance of further strengthening international cooperation in order to reach broad and efficient collaboration in this field for the mutual benefit and in the interest of all parties involved,
>
> *Desirous* of facilitating the application of the principle that the exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interest

> of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind...

Note that the drafters of the resolution cite the legal ideas of the 1967 Outer Space Treaty with no mention of the 1979 Moon Agreement and its specific commons designation. The resolution does, however, evoke the experience that has been gained over the years in international cooperation in all its public and private forms. In the recent years, this cooperation has become increasingly commercial and multinational.

The entire document emphasizes the strengthening of the status quo; the resolution's first article defines the international regime to which the nations should commit themselves in search of this goal of more complete international cooperation. Once again, there is the absence of the Moon Agreement and its common heritage of mankind language. Article 1 of the Annex of the resolution states:

> International cooperation in the exploration and use of outer space for peaceful purposes (hereinafter "international cooperation") shall be conducted in accordance with the provisions of international law, including the Charter of the United Nations and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. It shall be carried out for the benefit and in the interest of all States, irrespective of their degree of economic, social or scientific and technological development, and shall be the province of all mankind. Particular account should be taken of the needs of developing countries.

One subtle change in this language may be that the activities should be carried out in the interests of all states, instead of the interests of all mankind. This change suggests added clout to the nations in sharing the benefits of space, as the articles in the rest of the resolution make clear. It also indicates that the spacefaring nation continues to retain control over its space activities and its interpretation of obligations under international law.

The drafters, by their silence as much as by their words, accept the present situation in which each nation and, to a lesser extent, each corporation decides for itself the meaning and parameters of "benefit of all mankind" requirement. For instance, the text of Article 2 does require that any contracts be "fair and reasonable," but peer pressure in an increasingly interdependent

world economy already require and even define the required levels of such fairness and reasonableness.

> Article 2. States are free to determine all aspects of their participation in international cooperation in the exploration and use of outer space on an equitable and mutually acceptable basis. Contractual terms in such cooperative ventures should be fair and reasonable and they should be in full compliance with the legitimate rights and interests of the parties concerned...

This formula of an equitable and mutually acceptable basis appears again in the very next section, Article 3, in the context of granting between or among the involved states the status of arbiter of "equitable and mutually acceptable" terms.

> Article 3. All States, particularly those with relevant space capabilities and with programs for the exploration and use of outer space, should contribute to promoting and fostering international cooperation on an equitable and mutually acceptable basis. In this context, particular attention should be given to the benefit and the interests of developing countries and countries with incipient space programs stemming from such international cooperation conducted with countries with more advanced space capabilities.

Notice, not only the use of the mutually acceptable language, but also the use of the verb "should." In diplomatic language, even more than in every day language, the use of the word "should" rather than the word "shall" denotes a goal rather than a command. Indeed, throughout the history of international space law, many examples of this same semantical consideration are present.

Article 4 reinforces this interpretation, both as to nations and as to corporations. Indeed, it endorses the present experience by suggesting an almost unending assortment of relationships that may be permissible in the development of outer space by humankind. And again, it leaves the decision about the "effectiveness" and "appropriateness" of the method of development up to the involved parties.

> Article 4. International cooperation should be conducted in the modes that are considered most effective and appropriate by the countries concerned, including, inter alia, governmental and non-governmental;

> commercial and non-commercial; global, multilateral, regional or bilateral; and international cooperation among countries in all levels of development.

Nonetheless, the remaining half of the resolution, articles 5 to 8, does place restrictions or requirements on these international efforts. Still, it should be pointed out that all of these restrictions are already part of the accepted framework of international cooperation that has developed as part of customary and written international space law.

> Article 5. International cooperation, while taking into particular account the needs of developing countries, should aim, inter alia, at the following goals, considering their need for technical assistance and rational and efficient allocation of financial and technical resources: promoting the development of space science and technology and of its applications; fostering the development of relevant and appropriate space capabilities in interested States; and facilitating the exchange of expertise and technology among States on a mutually acceptable basis.

The admonition to take into account the needs of developing countries was inherent in the "benefit sharing" language going back to the 1960s; NASA and other space agencies, for political reasons, have always been solicitous of this concept. As an underlying factor in UNCOPUOS agenda items, "benefit sharing" language has been part of the diplomatic norm for almost twenty years. The resolution does not change this status-quo; it only reinforces that norm with diplomatic legitimacy.

> Article 6. National and international agencies, research institutions, organizations for development aid, and developed and developing countries alike should consider the appropriate use of space applications and the potential of international cooperation for reaching their development goals.

This article admonishes any organizational body involved in space to consider cooperation as a means to fulfill its plan. The admonition to "consider" such issues is hardly a burden on a spacefaring concern since such

cooperation generally advances the foreign policy goals of the spacefaring nation.

The last two articles seek to strengthen the international institutions in the UN that oversee such cooperative ventures. Again, both articles seek laudable goals, the language is not obligatory; the drafters only state that these goals "should" be accomplished.

> Article 7. The Committee on the Peaceful Uses of Outer Space should be strengthened in its role, among others, as a forum for the exchange of information on national and international activities in the field of international cooperation in the exploration and use of outer space.
>
> Article 8. All States should be encouraged to contribute to the United Nations Program on Space Applications and to other initiatives in the field of international cooperation in accordance with their space capabilities and their participation in the exploration and use of outer space.

Launch Industry Case

Resolutions state the lofty goals of the national parties and set standards that could become customary international law and then codified treaty law in the future. The worldwide practices of nations, and also corporations, may be evolving just such a change in international space law not only in relation to remote sensing, as discussed earlier, but also in regard to the launch industry. The launch industry is undergoing reorganization with major implications for international space law, politics, and economics. A major theme in this era of globalization has been the transnational consolidation and coordination of the industry as exemplified by the Sea Launch example.

In the late 1980s, the European and French Arianespace had almost two-thirds of the market for civilian commercial launches. Rocket companies from the US were struggling to hold on to a share of the remainder. At the same time, with the end of the Cold War, Russia had begun to try to market their launch vehicles. The US negotiated an agreement with Russia limiting the number of launches of commercial satellites and limiting how much they could undercharge for their launch services. The philosophy behind this was that Western companies would be unfairly disadvantaged because Russia had not had a market economy.

Today, it is unlikely that the US will renew the agreement, which has since expired. More so, US and Russian companies have become corporate

allies and partners in efforts to unseat Arianespace as the premiere launch company in the world. Lockheed Martin with International Launch Services and Boeing with Sea Launch have established such alliances. Arianespace and other European companies have also negotiated alliances with Russian companies. The world players and the market for space transportation has become increasingly competitive and fluid, leading to these transnational alliances.

International Space Station Case

Nowhere is this transnational dimension more evident than in the legal regime that was established for the International Space Station (ISS) among the national space agencies of Canada, Europe, Japan, Russia, and the US. The ISS agreement among these partners (Intergovernmental Agreement, IGA) provides for a complex set of legal arrangements. More specifically, the IGA establishes a common legal regime pertaining to intellectual property rights, jurisdiction and control, liability, and customs. This legal regime evolved over time from a 1988 IGA for what was then called Space Station Freedom[23] to the ISS IGA of 1998.[24]

The foundation for intellectual property deals with jurisdiction for activities on-board the space station.[25] A territorial approach to jurisdiction based on the extension of national laws to intellectual property rights was codified in the 1988 IGA.

> "...for purposes of intellectual property law, an activity occurring in or on a Space Station flight element shall be deemed to have occurred only in the territory of the Partner State..."[26]

This allows for legal certainty and predictability as to whose national laws of intellectual property rights are applicable.

There exists as well a specific limit to national jurisdiction over intellectual property. This dealt with the concept of "freedom of choice" concerning an invention by a person who is not a national of the flight element in which the invention was made. For Space Station Freedom, a partner state could not have automatically applied its national laws. As a rule of thumb, the owner of an invention could have filed for a patent and acquisition of ownership in any country irrespective of territorial considerations. The one caveat is that the permission for filing a patent, which must be granted to the inventor, had to be obtained from a designated

national official responsible for administering export control laws. Moreover the "freedom of choice" concept did not prejudice the rights of any partner state where the patent application is first filed.[27]

Jurisdiction and control of elements are conferred on a sovereigr basis (i.e., both territorial and national) in accordance with international space law. The Outer Space Treaty states:

> "A state party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body."[28]

For the space station, this law is applied over elements and nationals that are provided by a state and is also true of intellectual property and criminal jurisdiction: "...each Partner shall retain jurisdiction and control over the elements it registers...and over personnel in or on the Space Station who are its nationals."[29] For example, NASA was granted authority to exercise criminal jurisdiction over any personnel for misconduct that endangers the safety of the core station (technological infrastructure) to which it is legally obligated to provide by the 1988 IGA.[30]

As it applies to claims of liability, sovereign limits are in place whereby partners agreed to waive all claims (i.e., a cross-waiver of liability) based on damage to a person, entity, or property arising out of "protected space operations" (i.e., space transportation and space station activities).[31] Although, there are a number of notable exceptions to this cross-waiver of liability involving the permission to issue claims for one's own chain of related activities, injury or death, and damage caused by willful misconduct. On the other hand, for customs provisions sovereign rights are reinforced. It is incumbent upon each partner to facilitate the movement of persons and goods to implement the IGA subject to the particular state's national laws and regulations.[32]

The 1988 legal regime underwent a revision in the 1998 IGA. Though each partner retained sovereign jurisdiction, in terms of ownership and intellectual property, and the responsibility for developing and building the elements that they provide, revisions for criminal jurisdiction, liability provisions, and customs took place. In the matter of criminal jurisdiction, the sovereignty-based regime that was applied in 1988 was modified from one that was rooted in both territorial and national rights to one that places nationality as the primary determinant. The 1998 IGA states that the partners may exercise criminal jurisdiction only over personnel who are their

respective nationals.[33] Further, criminal jurisdiction applies in all cases with no unique rights provided for any partner.

The 1998 IGA provided a remedy for the problem of concurrent jurisdiction, jurisdiction for affected partners over their non-nationals, which was not resolved in the 1988 IGA. Partner states agreed that if the criminal activity "affects the life or safety of a national of another partner state" or "occurs in or on or causes damage to the flight element of another partner state," then the affected partner may exercise jurisdiction.[34] This right is granted provided that consultations with the partner whose nationality is that of the perpetrator takes place, and that this partner concurs or fails to provide assurances that it will pursue the case.

The sovereignty regime for the cross-waiver of liability was extended to include relationships with other partners not party to the IGA.[35] This extension was primarily inserted to cover the fact that launches in support of space station take place in Kazakhstan– a state that is not a partner but is a related entity of Russia through a treaty governing the use of the Baikonur launch complex.[36] The sovereign right to issue claims was expanded to include, in addition to claims regarding injury, death, damage caused by willful misconduct, and intellectual property, claims for damage resulting from a failure of a partner to extend the cross-waiver of liability to its related entities and partners.[37]

Also, the 1998 IGA established a mandatory duty-free customs legal regime.

> "Each Partner State shall grant permission for duty-free importation and exportation to and from its territory of goods and software which are necessary for implementation of this Agreement and shall ensure their exemption from any other taxes and duties collected by the customs authorities."[38]

This contrasts with the voluntary duty-free regime provision in the 1988 IGA.

The 1998 IGA for the ISS is indicative of a multilateral legal regime that has emerged in the modern period of space law. This case study illustrates that consensual and contractual law between states can represent important legal norms for emerging multinational and transnational space laws.[39]

CONCLUSIONS

Space activities have become increasingly multinational and transnational. As the theme of this book indicates, the focus of space policy has evolved from the political and military to include the commercial. The new economic reality in space has resulted in the formation of transnational corporations and international joint ventures. This accelerating transformation has undermined many of the nationalistic and other ideological underpinnings of existing international and domestic space law.

If space law of the classical period met the needs of that era’s highly centralized, nationalized space effort, if the transitional period drifted with the changing nature of the conditions in space, the law in this modern period necessitates a new philosophy that accounts for the current technological, political, and legal reality. Even though nationalistic and military considerations will remain vital into the foreseeable future as they apply to space, the multinational aspects of technology integration and development driving space commerce and international space endeavors like ISS demand a more transnational approach to space law. Both political and market forces set the stage for the future development of space policy and law.

Finally, because space commerce has become an important and growing segment of the world economy, like any other branch of the world’s business, it needs to be regulated and supervised to ensure a rational and efficient marketplace, and a peaceful arena for world affairs. This is the task of the space policy decision-maker, the space lawyer, and the space businessperson. Only by studying the trends in space policy, commerce, and law can the space community be prepared for this competitive present and future.

10
ECONOMICS OF SPACE

Molly K. Macauley*

INTRODUCTION

Exclusively economic criteria govern the conduct of very few activities, yet there are even fewer activities in which economics does not play at least a part. The "economics" of space means the hosts of values and costs that are associated with space activity, from space transportation and space-based telecommunications, to planetary exploration, and research and development (R&D) activities that take place on the space station. These values and costs come into conflict by virtue of natural limits– humankind generally does not possess the resources (time, money, people, technology, natural resources, and know-how) to do everything about which it can dream, and certainly this is perhaps no more so than in the case of pursuing visions for doing things in space. Often, resource limits posit constraints and economic choices among various options have to be made. How choices for space activities are made– matching "wants" with "abilities"– is what is meant by economics of space.

At the outset it is important to distinguish "economics" from "commercialization," the latter being the subject of the next chapter in this book. Commercialization represents the activities undertaken by private sector companies as distinguished from governmental activities. Economics and commercialization naturally overlap. For example, space transportation and space-based telecommunications are carried out by both the commercial and government sectors of the economy, and government regulations govern commercial space activities from launches to frequency allocations. The tools of economic analysis are useful in measuring the profit and loss associated with commercial activities and in designing cost-effective government regulation of those activities. Concomitantly, economic thinking addresses broader questions that affect society quite widely and transcend commercialization, such as how to measure the value of space research undertaken simply for the pursuit of knowledge, not necessarily commercial gain, and how to manage space debris to ensure that the space environment is preserved for future generations.

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This chapter offers an introduction to the variety of ways in which economics can contribute to understanding the value of space. In the first section of this chapter, the role of the space program in the national economy is discussed. Here, the common conception is that space is beneficial to a nation's economy and through multipliers and spin-offs that promote economic growth. But is this the case? And if not, what other benefits justify expenditures for space?

Second, the chapter turns to space as a place for public sector activities, such as exploration and the pursuit of knowledge for the sake of knowledge, and discusses approaches that economists use to frame the value of intangible benefits associated with such activities. Do the benefits justify what taxpayers spend on space exploration?

Third, space as a natural resource subject to scarcity is examined. Space may be vast, but some locations in space, such as the geostationary orbit (GEO), are unique, limited, and in demand. No one owns GEO, so how might its scarcity be managed to best exploit its significant economic benefits?

Fourth, space as a location for public infrastructure, using the International Space Station (ISS) as an example, is probed. ISS is but one of many public facilities that are likely to be constructed in space; other facilities may someday include power depots to fuel space-based activities or inter-satellite communications networks. Such facilities are expensive not only to build but also to operate. What steps might be possible to get the most use from this infrastructure?

Finally, activities in space tend to leave their mark in the form of space debris– a growing, but manageable problem. In the discussion of space as a resource subject to the "tragedy of the commons," lessons from environmental management on Earth are applied to suggest effective approaches to preserving space for future generations.

SPACE AND THE ECONOMY

A report by the United States (US) Congressional Budget Office (CBO) in 1994 discussing the role of NASA in the US economy states:

> How NASA affects the US economy is likely to consume a large part of any debate about the Agency's program. The problems involved in assessing the direct benefits that NASA provides have led some advocates of continued increases in spending for the Agency to claim that the indirect influence of NASA's program on the economy is sufficient to justify its cost.

Much of that report is the basis for discussion in this section. While the focus is on NASA and the US economy, the concepts described here carry over as well to the space programs in other states.[1] A common perception is that NASA expenditures in particular and space activities more generally directly affect the economy as a source of employment (for example, the number of jobs in aerospace), and through the new technologies that are "spin-offs" from space technologies creating a "multiplier" effect on the economy. Are these accurate portrayals?

Employment

Addressing employment first, the common perception is in fact a misperception. Space activities are often judged as being good for the economy on the basis of their job-creating potential. Of course, space-related jobs are a cost, not a benefit, to the taxpayers who are not employed in the federal space program. As economists agree, wages belong on the cost side, not the benefit side, of the accounting ledger. For this reason, jobs are not properly the basis of measuring benefits of space activities. In other words, the cost of carrying out any activity– the labor, facilities, and operations– is an expense whether carried out by the public sector (the government) or a private sector company.

Even if one wanted to make the case for space as a source of aerospace jobs, given that the bulk of space-related jobs are in aerospace (defined according to the US census as those jobs associated with manufacture of guided missiles, space vehicles, and parts, and not including the aviation industry), the effect on the US economy as a whole is minimal. Aerospace employment was about 108,000 during the 1990s. During much of that time period, total US employment has been close to full employment- about 123,060,000. So, even if the number of aerospace jobs were to double, they would still account for less than 0.1 of one percent of total employment.[2] A further argument against job creation as a rationale for space activities is that, ironically, many of the new technologies developed through space R&D can be considered "labor-saving." These jobs allow producers of goods and services to employ fewer people and maintain or even increase production levels. Examples are robotic techniques and automated instrumentation.

Multiplier

Another prevalent view of the economic effects of space activities is that they have a "multiplier" effect. The multiplier describes a relationship among activities in which one activity causes a host of other activities to take place, thus rippling the effects throughout the economy. For example, restaurants and hotels near the Kennedy Space Center in Florida benefit from expenditures by visitors going to the Center to view Shuttle launches. The problem with this approach is that it counts as benefits what are in fact merely transfers of income from some consumers and producers to other consumers and producers. It also overlooks other, less desirable transfers of economic burdens like traffic congestion and higher prices for residents near the NASA Center. Worse, if enough secondary effects like this are added to the primary activity (in this example, the Space Shuttle program), the multiplier can be large for any activity and hence sheds no light in discriminating among the economic value of different activities. For all of these reasons, the multiplier concept is a very poor guide to making public expenditure decisions.

To take an example, one of the most frequently quoted estimates of NASA's contribution to economic growth is that for every $1 of NASA spending, $9 is returned to the economy over a roughly twenty-year period.[3] Subsequent studies have refuted this conclusion. They have shown that NASA spending affects the economy no differently from other types of federal spending for goods and services, and that in many cases, these effects may or may not have a positive return. The problems with the multiplier approach are so acute that the US Office of Management and Budget (OMB), confronted with frequent use of the multiplier by many government agencies, has issued guidelines for evaluating the benefits and costs of federal programs. OMB states with regard to multiplier effects: "Employment or output multipliers that purport to measure the secondary effects of government expenditures on employment and output should not be included in measured social benefits or costs."[4]

Spin-offs

If employment and multiplier effects are arguable, then, what about contributions the space program has made in the way of new products? As the CBO observes, these so-called spin-offs have become part of the mythology of space projects. For instance, each year since 1976, NASA publishes a report, *Spin-off,* highlighting "the down-to-earth benefits" of the space program. The introduction to *Spin-off 2000* notes that "...return benefits– spin-offs– represent a significant dividend to the taxpayer and the

nation's investment in aerospace research." The 2000 issue included a robotic arm for assisting surgeons and new software for designing ceramic coatings that could be applied to turbine engines.

Since the 1980s, congressional amendments to the NASA Space Act have encouraged the Agency to move beyond undertaking fundamentally space-based activities to a broader role in providing new technologies for commercial markets on Earth. However, economists urge caution about the use of spin-offs as an appropriate measure of the benefits of space activities.

The argument offered by critics is that if consumers wanted these new products, then funding R&D specifically directed toward these products would probably be much less expensive, and be successful much sooner, than obtaining the products by way of spending on space projects. In other words, while spin-offs may bring social benefits, their costs of development undertaken indirectly as a part of a space project is more expensive than their costs of developing them directly. For this reason, spin-offs, like multipliers, are poor measures of the contribution of space activities to the economy.[5]

Other Approaches

In further attempts to understand the role of NASA activities in the economy, several studies have statistically estimated a production function, a mathematical relationship that relates inputs to outputs, in attempts to quantify NASA's contribution to overall economic productivity. These approaches seek to explain overall macroeconomic growth on the basis of several variables, including federal expenditure on space activities.

The studies have found that the contribution is insignificant. In summarizing some of these studies, the CBO notes that the short-term economic effects of expenditures on space activities are no different from those of other federal spending. This determination is not surprising, since it is hard to see why federal spending on space activities should spur the economy more than, say, federally funded highway repairs. Nor do the studies find any evidence of long-term productivity gains to the economy from space activities. There may well be productivity gains in some industries (such as in telecommunications, as the result of communications satellites), but these positive effects have been due, in large part, to significant industry investment rather than to federal spending.

The CBO notes that this result is neither surprising nor indicative of a waste of resources. Indeed, the economic value of space activities may elude measurement by employment, multiplier, spin-offs, and statistical models.

Are there any other alternative approaches? The next section turns to this question.

SPACE AS A PUBLIC GOOD

Space as a Locus for Providing Public Goods

A host of activities take place in space for the general benefit of humankind, including the use of space for national defense, environmental monitoring, and the collection of science data and information. According to the legislation that established NASA in 1958, the US space program is to expand knowledge about Earth's atmosphere and about outer space, develop and operate space vehicles, preserve the leadership of the US in inventing and applying aeronautics and space technology, and cooperate with other nations in space projects. Indeed, space R&D is a large function of NASA (about 67% of its budget in 2000), and federal government spending on R&D in space is a large share of the overall federal R&D spending. As a percentage of total R&D funding (by both the federal government, industry, and other sectors), space-related funding reached a peak of 22% in 1965, declined to a low of 3% in the mid 1980s, and now hovers around 4 to 5%.[6] Figure 10.1 illustrates these trends in US federal government spending on R&D.

Special Aspects of Public Goods

A special characteristic of activities that produce public goods is that many people can benefit from them simultaneously without reducing their availability to others or adding to the costs of these activities. For instance, the benefits of R&D are available to everyone in the nation, and increasing the number of citizens who benefit from the activities does not increase the costs of the activities. Activities with this type of attribute are known as public goods. Other activities, for instance supplying transponders on a communications satellite for telecommunications, do not have this characteristic. In that case, providing a transponder for one more consumer would add to the cost of the satellite.

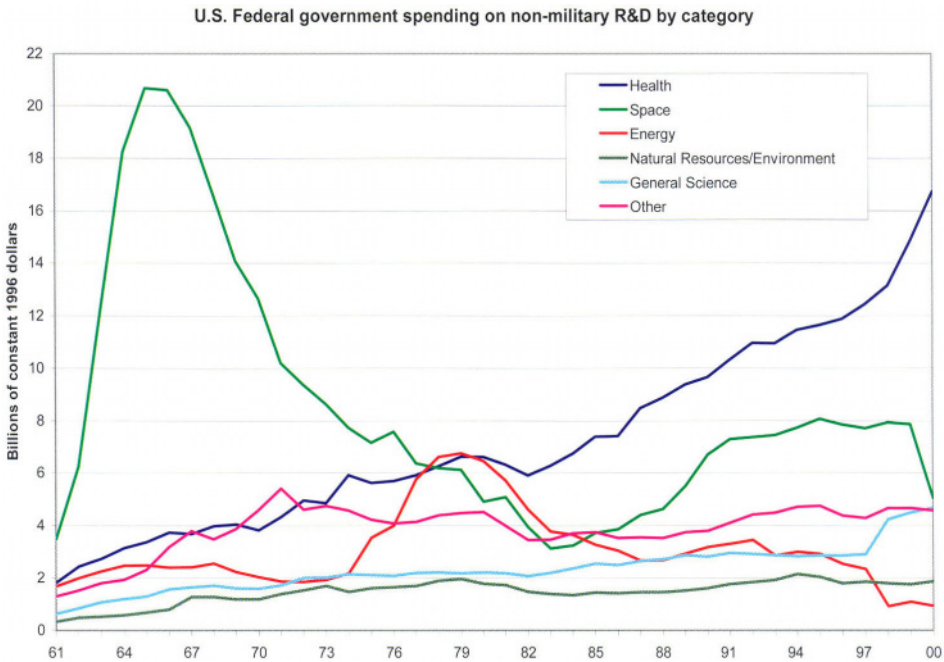

Figure 10.1. US Federal Government Spending on Non-Military R&D by Category. Source: National Science Foundation.

Measuring the Value of Public Goods

One of the challenges of policy-making for public goods is that it is difficult to know when just the right amount is provided for the citizenry. To put it simply, how might one determine if the amount of money that is funding federal space R&D is the "right" amount? Unlike goods and services that consumers and producers buy and sell in the market place, public goods generally do not carry a price tag that the public can see very easily. These goods are not free, rather they are paid for through taxes. On a per-household basis, the average amount of taxes going to the space program is about $116. When surveys ask individuals if they would like to spend more of their taxes on space (but not increase how much tax they pay in total), many say "yes," but are hard-pressed to decide which of the other activities to cut back.[7]

In an attempt to help inform the public about the benefits of space, and thus, increase the willingness of the public to fund space, the approaches

to measuring benefits described above have come about. Clearly, these approaches have disadvantages, and they are largely ineffective in assessing the "public goods" benefits of space. A gap in space economics research is that studies have yet to directly measure the national prestige, geopolitical influence, vicarious thrill of exploration, or elevation of the quality of understanding concerning the solar system and other space science–intangible benefits that many associate with space exploration. To ignore these intangible values underestimates the benefits of space activities.

Are intangible benefits estimable? Yes, with caveats. In fact, they are frequently analyzed in a host of federal programs. For example, the Army Corps of Engineers is prominent among government agencies for attempting to measure all of the tangible and intangible benefits and costs of the environmental effects of its engineering projects. To illustrate: an acre of wetland might trade in the real estate market on the basis of its value for commercial development. But this value could be quite different from the value of the land as a means of controlling floods, recharging groundwater aquifers, or serving as wildlife habitat. These benefits from wetlands preservation are very hard to measure but the Corps takes good steps towards this end.

Contingent Valuation

At the heart of most approaches for estimating the difficult-to-measure value of natural resources or other non-marketed goods is a method known as contingent valuation (CV). This involves the development, administration, and analysis of sophisticated surveys designed to elicit valuations of goods and services for which no market prices exist. The name, CV, refers to the simulated market-like setting presented in the survey and upon which the values expressed by the respondents are "contingent." CV surveys typically supply information to respondents about the good or service they are being asked to value, but in a way that does not bias the respondents in reporting their valuations.

For example, one of the most detailed CV surveys ever constructed was used to assist decision-makers in understanding public values associated with the wildlife, wildlife habitat, and natural environments that were affected by the oil spilled during the accident involving the Exxon Valdez oil tanker in 1989. In that application of CV, as in a typical CV process, respondents to a survey were asked how much they would be willing to pay each year in order to preserve these resources. So, one way CV could be applied to space activities is by asking respondents how much extra federal income tax they would be willing to pay each year to finance additional space activities. The

survey would describe these activities and the scientific knowledge or other benefits expected to be gained from them, as well as some activities that would have to be foregone unless total tax liabilities were to increase.

CV methodology is at the frontier of economics research.[8] Like any frontier research, it is controversial, and not all of the problems have been worked out yet. If CV surveys are to provide useful information, they must meet many conditions. One is that the survey respondents fully understand the public good they are being asked to value. But many Americans are not necessarily well informed about the space program or what it has already revealed about space.

Information collected by the National Science Foundation (NSF), from 1979 until the present, indicates that a majority of US citizens do not understand the nature of the Solar System or the origins of stars or galaxies. In the 1992 edition of a statistical compendium published annually by the NSF, *Science and Engineering Indicators,* the agency concludes that "...American understanding of science is, indeed, rather Earth bound." This conclusion poses a dilemma to policy-makers. How can they determine an appropriate space budget when they cannot reconcile this apparent lack of understanding with the values implicitly attributed to space projects in congressional legislation and public discussion? Nonetheless, the CV approach may well offer promise for helping to clarify public understanding of the intangible values associated with space activities. In the administration of the survey, a key step is a clear description of the good being valued. A well-executed survey may even shed light on the magnitude of the values of the goods.

Informal Approaches

During the 1990s, the annual federal space budget has ranged between $13 and $16 billion (adjusted for inflation). Each year during this period, approximately $1to $2 billion has been the subject of significant debate in the budget process.[9] Suppose individuals were asked to decide how best they would like an additional $1 billion to be spent in federal programs, if the goal were to foster some of the less tangible benefits associated with space activities. For instance, suppose that $1 billion is to be allocated to a space project undertaken with Russia and other countries of the former Soviet Union, in part to foster collaboration and mutual economic benefit. The effectiveness of this approach to international cooperation could be tested by asking individuals if allocating $1 billion to the space project is just as likely

to help countries prosper as an outright doubling of the US budget typically allocated in direct aid to these countries (during the 1990s, around $1 billion).

Alternatively, if space projects were considered by the public to be a source of new knowledge, another use of $1 billion would be to quadruple recent federal spending levels on ground-based astronomy and physics. Another comparison of alternative projects might help to clarify debate about intangible benefits of space activities such as promoting education more generally. For example, $1 billion would double federal spending for college-level science and engineering programs or double the federal contribution to higher education. Or it would fully fund the college education of some 20,000 students. Would such programs be more effective stimuli to education than space-related activities? As in the case of space projects, each of these alternative projects could claim its own intangible benefits, spin-offs, or spill-over effects, such as contributing to national economic health and international competition. What must be articulated in public debate is when and to what extent space activities better meet the same goals.

SPACE AS A RESOURCE SUBJECT TO SCARCITY

This discussion of how, and how not, to frame the economic benefits associated with the array of benefits from space is the starting point for most people's conception of space economics. However, there is more to be contributed by economics to space policy, and this section offers some illustrations. Even though space is typically thought of as a vast, infinite frontier, it is in fact is a heterogeneous place. To take an easy example, different orbits are better for some activities than for others. Low Earth orbit (LEO) is useful for remote sensing and space station activities, while GEO is utilized for telecommunications and meteorological satellites.

Geostationary Orbit

To further illustrate the varied nature of space as a resource, not all locations along the GEO orbit are equally desirable. Only from some locations can a satellite interconnect the US and Europe, and many locations command field-of-views only of the oceans– important for weather data collection, but much less useful for intercontinental telecommunications. There exist annual values of different locations from which all or part of the countries in the Pacific Rim and the west coasts of Canada and the US are in the field of view of a satellite.[10] This region has been the subject of

contentious debate over GEO orbital allocations as communication demands there have increased markedly during the 1980s and 1990s.

Satellites in GEO are located according to the degrees longitude coordinate along the Earth's equator. The annual value of the orbital slot is estimated by a statistical model of population, income, and demand for international and domestic telecommunications on the part of people in the states that can be serviced by a particular satellite. The value is largest at about 190 degrees longitude, as a satellite situated there has within its field-of-view all the Pacific Rim countries and the west coasts of Canada and the US. As the satellite moves east, parts of these countries or entire countries are outside the satellite's field-of-view. Expanding the field-of-view incurs extra costs, such as for undersea fiber optics or another satellite, which would reduce the value of the orbital locations. A graph of these GEO orbit values is shown in Figure 10.2.

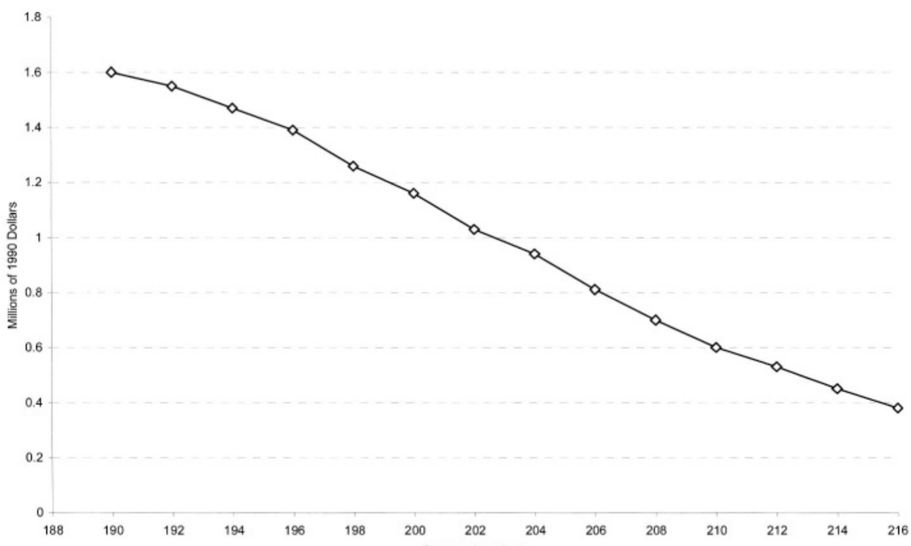

Figure 10.2. Estimates of the Economic Value of Geostationary Orbit for Countries in the Pacific Rim.

GEO locations are in high demand. Both the International Telecommunications Satellite Organization (Intelsat) and the International Telecommunications Union (ITU) oversee access to GEO in terms of orbital and frequency allocations, and governmental agencies in states around the world allocate these resources through deliberations at national administrative

hearings. In the US, the Department of Commerce and the National Telecommunications and Information Administration coordinate allocations for defense, weather, and other US government purposes, while the Federal Communication Commission (FCC) has the task of making allocations to US domestic commercial users.

Because these allocations translate into large revenues for telecommunications companies, the allocation process is contentious.[11] Many observers have long advocated the use of more market-like approaches to allocation of GEO slots.[12] Such an approach might result in the more effective use of the orbit. For instance, larger-capacity satellites would have an incentive to purchase prime GEO real estate, and smaller capacity satellites could purchase slots that focus on telecommunications services to smaller geographic areas. Observers suggest the process might be fairer than international and domestic hearings fraught with debate and political influence.

As a successful precedent to such an approach, in the US, the FCC has begun to auction portions of the frequency spectrum as a means of assigning access to its use. As of 2000, these auctions have raised over $22 billion for the US Treasury. These allocations are for terrestrial based activities rather than space-based, but the approach may be a viable alternative for allocating GEO. It is also important to note that auctions of the electromagnetic spectrum can be fully consistent with achieving important non-economic goals associated with resource use. The license to use these resources can include designated public service obligations like weather forecasting and environmental monitoring.

SPACE AS A PLACE FOR PUBLIC INFRASTRUCTURE

Historically, and with the exception of commercial communications and remote sensing satellites, large space-based infrastructure has largely been funded and operated by governments. Economists have long advocated several guidelines for effective management of public infrastructure, in essence urging that the private sector be a role model for how governments should manage. Are private markets acceptable models for national governments? Can the market approach balance drives for efficiency and economic profitability with public policy objectives? In this section the example of ISS is explored.

International Space Station

As the first ISS modules were assembly in 2000, nearly 4,000 proposals had been submitted to NASA for station-based research. Of these, about 20% were selected for initial ground-based testing. Many fewer of these projects will be able to be selected for the next step, actual research time on the station, due to limited resources on the station.

How best to allot water, energy, communications, the handling of hazardous materials, laboratory space, and a wide range of other supplies and services to nearly as wide a variety of national and potential commercial users, such as the participating states, and other public and private-sector users, emerges as an economic problem for ISS. How resources are allotted, as ISS becomes fully operational, will go far in helping to realize the station's scientific, technological, and economic potential.

Might there be a use for price-like mechanisms to allocate station resources? In research undertaken in the late 1980s as plans for the station were developing, John O. Ledyard, Charles R. Plott, and their colleagues at the California Institute of Technology described the potential effectiveness of an on-line computer bulletin board by which station users would bid for sets of resources, such as power and water and for priority of their availability. The aim of this system would be to determine which of the potential uses are "highest valued" and to allocate resources accordingly. One advantage of this approach is that resource allocation would take place as the need for it arose rather than as pre-determined by the rationing of resources, which could lead either to over allocation or to under allocation of the resources.

NASA successfully developed a computerized exchange based on such an approach, under the guidance of Ledyard and his colleagues, to allocate resources (such as power and communications downlinks) on the Cassini spacecraft. For Cassini, the exchange assisted in sorting out priorities for the design and operation of the many instruments on the spacecraft and for the many experimenters managing them. Even earlier, in 1973, a somewhat similar approach was used to select the trajectories for the Voyager probes. Some eighty scientists who had experiments on the probes disagreed about the choice of trajectories, and a bidding-like mechanism (without an actual exchange of funds) helped determine the most-valued choice in terms of potential scientific research merit.[13]

Although bidding could encourage efficient allocation of resources in the shorter term, its applicability for longer-term issues, such as capital expenditure on additional equipment or appropriate new directions for technical change, is not clear. Users bidding for immediate resource requirements lack incentives to take into account the longer-term cost of

adding to ISS capacity. An additional charge on resource use would need to be levied to achieve this aim. Such a charge could be set equal to the expected price of augmenting station resources in future additions to ISS capacity, to best signal to users the resource cost of using more units of water, power, and so forth.

It should be emphasized that auction-like or price-oriented methods can include direct subsidies to scientific research undertaken for public benefit. In addition, depending on the economics of station technology, pricing resource use would not necessarily recover either operating or investment costs. Certain provisions, such as the establishment of minimum bids in an auction scheme, could be adopted in an effort to cover costs, but most observers expect the ISS to need government funding in order to operate.

Upon deployment of the first ISS modules in late 2000, NASA managers established a set of prices for commercial companies wishing to use the station. At that time, the standard price was $20.8 million for accommodating a payload, including electric power, some hours of crew time, and space-to-ground communications (space transportation is not included in this price). These prices presumably reflect a mix of real resource costs and a government subsidy, but the sizes of these two components is not clear. If the prices are too high, they discourage station use, and if too low, they misrepresent the actual cost of using the station. A "two-part price," that indicated the resource cost and also the extent of subsidy, might better communicate to users, NASA managers, and the taxpaying public a more balanced perspective of ISS costs. Even better might be an auction that could allow different customers (both in the public and private sector) to secure station use at bids reflecting the real value they place on station access and utilization.

To be sure, as long as ISS activities involve the public sector, the political process will play a role in governing the station irrespective of whether market-like mechanisms are selected for distributing the station's scarce resources. But political, technical, and economic issues are inextricably linked. Unlike the mindset that existed during Project Apollo, where political forces were marshaled for an abundantly funded technological effort, new perspectives must be brought to bear in managing the ISS infrastructure and the associated competing uses in an environment of scarce financial and physical resources.

SPACE AND THE "TRAGEDY OF THE COMMONS"

The desirability of space for a host of activities is obvious from the chapters in this book. Coupled with this desirability is the fact that no one (state or non-state entity) owns space. In international law space is defined as a "commons." A "commons" is characterized by non-appropriation (non-ownership), joint use, and joint availability (equal access to all). In other words, like the high seas and the atmosphere, space is an open resource for exploration and exploitation. The discussion of the economic value and desirability of locations in GEO hints at a problem: what happens when space becomes so much in demand that some type of custodial care of space is needed? This situation tends to arise with the high seas and with clean air. It is often called the "tragedy of the commons," in the sense that a resource that people share in common can become over-used and exploited to the detriment of all users– "everyone's property is no one's property."[14]

Since space is subject to joint use and availability any user may exploit the resource since exclusion is impossible or impractical. As a result, the resource value of space may diminish as a result of overuse or misuse. The costs and benefits associated with commons' use is likely to be distributed asymmetrically and it is even conceivable that those who benefit may not pay a use-cost, whereas those who suffer negative consequences from resource abuse may derive few if any benefits. The case of orbital debris informs a "tragedy of the commons" that could ensue in space.

Space Debris

For space, the problem of the "commons" is perhaps most notable in the growing problem of space debris. In 1993, the issue made national headlines when it was reported that the Space Shuttle Endeavor had to maneuver in order to avoid colliding with a spent Russian rocket. NASA, in fact, assesses the orbital debris risks on every Space Shuttle flight and has made numerous orbital corrections over the years to avoid collision. The same holds true for ISS, albeit the ability for orbital correction is more limited and has not as of yet (2002) been needed.

The millions of pieces of orbital debris that populate the space environment range from defunct spacecraft, spent rocket bodies, operational debris from satellites and other payloads, paint flakes, and particulates from propellant fuels. Collisions with large pieces of debris (>1.0 cm), which can produce catastrophic damage to spacecraft, are not the only source of concern. Even smaller debris (0.01 cm to 1.0 cm) can be destructive as they can

produce significant impact damage, which can be serious depending upon system vulnerability and defensive design provisions against debris. Even debris smaller than 0.01 cm cause surface pitting and erosion of materials. Moreover, the millions of debris particles less than the 0.1 cm size are beyond current capabilities (2002) to track from satellite or ground-based radar observing systems.

Officials in both the US and abroad have convened working groups, in particular the Interagency Debris Committee (IADC), to assess, monitor, and recommend policy and management strategies for space debris. How best can space debris be managed to preserve space for future generations? Must there be zero debris generated? Should space vacuum cleaners be designed and operated for clean up? The approaches taken by IADC, for example, encompasses alternatives ranging from the promulgation of voluntary actions that nations and industries might take to reduce debris, to the establishment of guidelines and standards to govern launch vehicles and their payloads.

Generally speaking, in the case of pollution, when it is unregulated, polluters will pollute excessively, enjoying the benefits of polluting activities, but not realize the costs (since they are borne for the most part by parties other than the polluters). Interestingly, the situation of space debris is somewhat different from this more general pollution problem. Debris generation is more likely to create mutual harm; that is, not only others but the generator as well may be impacted by the debris. Furthermore, debris begets debris. This "cascading effect," as debris models refer to it, occurs as debris collides with other objects or other debris and breaks into pieces and, that in turn, adds to the debris population. Related to mitigating the cascade effect is that shielding or other actions taken to protect a spacecraft from debris can also serve to reduce the additional debris generation from impacts that could occur if the spacecraft were not shielded. But shielding adds mass and expense to launch and operations. How much shielding is "worth it" from an economic standpoint?

The costs of mitigating debris include the costs of the mitigating activity, the costs of monitoring and enforcing the effects of this activity (monitoring and enforcement costs are often overlooked in public policy), and the longer-term costs of the mitigating actions on the pace and direction of future technological innovation in space activities (that is, if the actions retard or bias the development of new space technologies). These costs represent a mix of costs borne by the government or company engaged in the activity (the direct costs of the mitigation action, whether it is voluntary or mandated), and the costs borne by society more generally (the costs of debris in terms of potential impacts on other spacecraft operations, its contribution to cascade effects, and whether mitigating actions bias technological change). Private firms may take some of the direct costs of a debris impact into effect through

the purchase of insurance policies. Governments self-insure– taxpayers bear these costs associated with the debris problem when it involves government space activities.

How large might the potential economic impact of debris be? The costs include the replacement cost of the spacecraft, assuming it is irreparably damaged, and the cost to society more generally of the additional debris generated by collision with the spacecraft. These costs are properly adjusted for the probability of a collision, which varies by the space-based location of the activity and the debris population there; some orbits, for instance, are more heavily populated by debris than others and more permanent such as in geosynchronous orbit. The damages also include the loss of the services or research provided by the spacecraft until it is replaced, and if humans are involved, possibly a loss of life. The social expected loss value is the sum of the satellite's private value plus the potential future damage that is now associated with debris in GEO as a result of the collision. Private firms typically purchase insurance for their commercial satellites, but potential future damages are borne by society as a whole.

A variety of debris mitigation measures have been suggested. These include designing spacecraft to reduce the potential to break-up, venting excess propellant from launch vehicle components, using lanyards to secure external components, and boosting GEO satellites into disposal orbits. Additional options include modifying orbital parameters to avoid debris populations, shielding spacecraft and reducing their cross-sectional exposure, and developing technologies for active debris removal.

Balancing the costs of actions, such as these, with the benefits (or avoided damages) of maintaining the space environment is a difficult but important objective. Space is already an expensive location in which to operate, and debris mitigation can add to the expensive. For this reason, some of the approaches that have been taken to manage pollution on Earth may illustrate cost-effective ways to manage space debris. Many of these approaches involve the use of economic incentives to encourage debris reduction without undue cost.

For example, financial penalties could be levied for debris generation, much like a littering fine on Earth. Sometimes compensation can be linked with support for other activities, in which case it would not necessarily have to be financial but could consist of in-kind resources, such as technology transfer to parties harmed by debris. Taxes or fees could also be levied on space activities, including deposit-refund schemes (like those for glass bottles in many countries). Deposits could be made upon launch and later refunded when components are boosted to disposal orbits, successfully de-orbited, or when excess propellant is vented. Bonds could also be offered for space

activities and be redeemable upon proof of compliance with overall debris reduction goals (similar to insurance, but specifically linked to debris mitigation actions). Each of these options has an additional advantage in that the sizes of the fees, deposits, or bonds could vary depending on the orbit in which the activity is to take place, with smaller fees in locations that are less frequently used and where potential damages might be lower. The fees could also be discounted as an incentive to adopt techniques that deal with both protection and mitigation. Shielding, for instance, can operate to protect the spacecraft from debris, and to some extent contain the debris that would be generated should the spacecraft be impacted.[15]

All of these options, as well as voluntary and regulatory approaches, are centered on a target for a level of debris mitigation– a "livable" amount of debris. If individuals were asked what the most desirable amount of space debris is, the inclination of almost everyone is to say "zero." In fact, the fiscal year 1991 NASA Authorization Act included the following recommendation for zero debris growth:

> ...the sense of Congress that the goal of the United States policy should be that the:
>
> ...space related activities of the United States should be conducted in a manner that does not increase the amount of orbital debris; and
>
> ...United States should engage other space-faring Nations to develop an agreement on the conduct of space activities that ensures that the amount of orbital debris is not increased.

But attaining zero debris growth, or even cleaning up all debris, is likely to be prohibitively expensive and may well require cessation of doing anything in space. Further, it is not practical and technically feasible today. Pinpointing a "livable" amount requires a comprehensive social benefit and cost calculus, informed with engineering data about debris populations and their probable growth over time, to weigh the benefits of space activity against the costs of debris production and mitigation. Finally, debris issues, like all space activity, are inherently global. Choosing the best way to manage debris requires the consensus of all parties: those now using space, those who will use space in the future, and those who may never use space directly but who indirectly benefit from space activity.[16] An initial analysis of this problem of space debris management is outlined in Table 10.1.

Table 10.1. Comparison of Space Debris Management Strategies.

Key: The symbols "+" and "–" are assigned for the properties of the strategies in the following order: (1) likely to achieve sustainable growth rate; (2) minimizes compliance cost; (3) permits flexible compliance; (4) may be perceived as fair; (5) is self-enforcing. The "+" indicates more likely and the "–" indicates less likely.

STRATEGIES

Mitigation Activities	**Voluntary Actions**	**Taxes/ Fees**	**Performance Bonds**
Venting residual fuel and pressurants from discarded rocket bodies.	– + – + –	– + + – +	– + + + +
Boosting geostationary satellites into disposal orbits.	– + – + –	– + + – +	– + + + +
De-orbiting spent hardware at end of operational life.	– + – + –	– + + - +	– + + + +
Reducing operational debris.	– + – + –	– + + – +	– + + + +

CONCLUSIONS: MAKING ALLOCATION DECISIONS

Because economics involves balancing benefits and costs, it is important to note that benefits properly include intangibles, like the value placed on exploring the universe, as well as more tangible products like the services of communications satellites. Costs include not just the cost of hardware and operations, but also other less direct, yet nonetheless important costs, like the burden of the space debris that most space activities generate.

This chapter began by noting that economics is about making decisions when resources are scarce. Probably no other program is expected to meet as many disparate objectives as a nation's space program. In the US, NASA legislation and the publicly articulated values that have become

expected ends of space activities require the program to contribute to space science, improve understanding of the environment, advance space vehicle development, and develop space-based industrial manufacturing, to name but a few enterprises. Nor has any other program been directed to engage in so many activities, while at the same time pursue as many possibly conflicting objectives, such as scientific research versus commercial gain, technological innovation versus routine operation, international cooperation versus international preeminence. The public expects plenty from its space program.

Given high and diverse expectations on the one hand, and limited resources on the other hand, space policy decision-makers must decide which of the values associated with space activities they prize most highly and whether space projects or non-space projects are best suited to realize these values. Such decisions should inform resource allocation both within the space program and between the space program and other public policy programs. Intangible values might be a key factor in this allocation, but such values have yet to be directly measured. Doing so might ease the growing tension between demands for accountability in the use of public money and the freedoms granted the space program in the interests of science, technology, and other public gains.

11
SPACE COMMERCE

James A. Vedda*

INTRODUCTION

Entrepreneurial spirit aimed at space has been around since at least the beginning of the space age. For decades, there have been people who see outer space as more than just a research lab for the scientific and engineering elite, or a "high ground" for military and intelligence interests. They see it as a place ripe for economic development, an industrial park of unfathomable size.

Outer space is an environment fundamentally different from any other that has been developed by private sector interests seeking economic gain. In the business community, the glamour of space attracts some, but repels others. Economic viability still depends on many of the same factors that drive terrestrial endeavors. Private development efforts will attempt to make the most of opportunities in a realm where raw materials and energy are essentially unlimited, but success will still require making the best use of resources and human capital. Investors' expectations for timely and reasonable returns on their investments will not disappear as businesses move into space, nor will policymakers' interest and involvement in such activities disappear.

As in other commercial sectors, public policy must confront issues, such as public safety, resource allocation, and environmental protection, that may not be addressed adequately in a competitive marketplace, even one as vast as outer space. Launches and reentries must not endanger people or property; communications satellites must not interfere with each other's transmissions; space debris must not be recklessly scattered in Earth's orbit. And, governments will continue to be concerned about the availability of militarily significant space services to potential adversaries.

The terms "space commerce" and "commercialization of space" have been used to describe a variety of activities. For purposes of this chapter, these concepts are defined as the provision of products or services by the private sector, which are directly dependent on a space segment. A space commerce venture can result from "privatization." This refers to the shift of a

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publicly funded system, originally designed to fulfill government needs, to a private-sector owner or operator. This approach has had varying degrees of success in the space arena. Space commerce is exemplified by the following characteristics: private capital is at risk in development and operations; there are existing or potential non-governmental customers; market forces, such as demand and competition, ultimately determine viability; and primary responsibility and management resides with the private sector.[1]

Commercial activity in space has become a large and rapidly growing area of activity where technological prowess and marketing skills join forces in the quest for profitability. Space commerce has moved into the mainstream of business and investment, and public policy toward this sector of activity continues to evolve. Commercialization of space represents one fundamental policy change currently underway within the space program, one that is emphasized in this book.

EMERGENCE OF SPACE MARKETS

In the first decade of the United States (US) space program, NASA did not advocate the commercialization of space, nor was it directly concerned with economic development. Although the transfer of technology to benefit society was one of the Agency's original mandates, NASA was not called upon to demonstrate economic gains to justify its efforts until the waning years of the Apollo program. This shift in the civil space program's policy image became particularly evident during the developmental period of the Space Shuttle. When the capabilities and ambitions of the private sector had made a space commerce boom appear imminent, Congress amended NASA's charter by directing the agency to "...encourage, to the maximum extent possible, the fullest commercial use of space."[2]

US government policies toward space commerce actually began to take shape as soon as space became accessible. The Eisenhower Administration took a hands-off approach whereby industry was fully responsible for developing and operating space applications, raising doubt that government funding, or even access to government facilities, such as launch ranges, would be available to facilitate the private sector's entry into space.[3] With the Kennedy Administration, space development was a tool for strategic and foreign policy and hence, government funding was provided for satellite communications research and access to government launch capabilities.[4] The most visible and lasting actions of the Kennedy years relevant to space commerce were the events and legislation which initiated rapid satellite communications development.[5] Among these actions were the creation of the Communications Satellite Corporation (Comsat), a quasi-

private entity that initially held a monopoly on US satellite communications, and the International Telecommunications Organization (Intelsat), that spread satellite services around the world. The Kennedy Administration's goal was to use the nation's technological prowess to win the minds and hearts of non-aligned nations. The gestation of space commerce was a fortunate by-product. In addition to satellite communications, governments have played a role in fostering commercial activities in remote sensing, global navigation satellite services, and expendable launch services.

Satellite Communications

Over the last four decades, satellite communications have become a commercial success. The reasons for this success are clear. Communication is an inherent part of human activity, so better communication– faster, easier, more affordable, more flexible, and more extensive– is always a marketable idea. Each time in human history that better communications techniques were developed, they quickly gained wide acceptance, not only improving existing services, but also creating new ones. Orbiting satellites are another step in that continuing evolution, so their success should not be at all surprising. For decades, communications satellites have demonstrated greater capabilities and substantial reductions in user costs. What is more, this sector of activity continues to grow as it develops new markets and services around the world.

The emergence of satellite communications had several political and economic advantages that made success all but inevitable. First, demand for communications is universal. Every individual needs and wants to communicate, as does every business and government agency. People are eager to communicate with each other even in situations where they are not making money at it. Satellites provide an additional and often better way to serve this need. Second, most of the communications infrastructure, both physical and regulatory, was already in place when satellites appeared. Once satellites were launched and ground stations were built, it was a simple matter of plugging them into existing networks, particularly in developed countries where large numbers of customers were ready to take advantage of the new services. Third, the promise of a global network was promulgated by the Kennedy Administration,[6] and backed up with enabling legislation and solid funding for research and development (R&D). Strong government support and public awareness are a powerful combination, especially when ongoing economic benefits are visible. For well over a decade after they were first put in place, communications satellites catered primarily to public telephone networks and television distribution for national broadcasters. Since the

1980s, however, the number and diversity of services has grown so that new market development will flourish for years to come.

Like the other government-developed space capabilities that eventually would become commercial, satellite communications has had its policy fluctuations, and even reversals. In 1972, the Nixon Administration decided that R&D for satellite communications would no longer be supported by NASA funds. At the same time, the Federal Communications Commission (FCC) ended Comsat's monopoly on domestic (but not international) satellite links.[7] Later, the Reagan Administration further changed the commercial satellite communications landscape when the FCC declared that US companies could independently offer international service if they already had downlink footprints which overlapped foreign countries. This was followed soon after by permission to compete for international business in telecommunications services other than connections to the public telephone network, further eroding Comsat's monopoly and Intelsat's dominance.[8] More recently, as Intelsat privatized to become more competitive, Congress sought to hasten the privatization process of telecommunications services in the US through legislation that set privatization milestones and threatened sanctions if they were not met.[9]

All of these policy changes can be interpreted as the growing pains of a young, but maturing industry. Albeit satellite communications has had commercial success, other space applications, remote sensing, global navigation satellite services, and launch services in particular, followed a more troublesome evolutionary path. This path was earmarked by ad-hoc policy-making that produced political and legal inconsistencies, which often mitigated against the commercial development that was intended.

Remote Sensing

Imagery of the Earth from space has a large array of applications– in mapping, urban planning, resource exploration, environmental stewardship, and agriculture– leading one to believe that it should enjoy commercial success comparable to that of satellite communications. But the economic value of remote sensing is often difficult to capture since it requires special training, and thus capital, to turn raw data into useful information (i.e., value-added data). Today, some of those skills can be encoded in software and run on ever-more-powerful personal computers, but this was not the case for most of the history of remote sensing. Policy-makers typically have had a poor understanding of remote sensing capabilities and potential, resulting in ill-conceived policies and unsteady governmental support.

Remote sensing also lacked other advantages that sparked the rapid acceptance of satellite communications. While demand for overhead imagery is large, it is far from universal. The product itself is poorly defined, in sharp contrast to homogeneous services like telephone calls or television broadcasts. No physical or regulatory infrastructure to aid implementation was in place when civil remote sensing emerged on the scene, and even today a fragmented community exists that often acts in counterproductive ways. And with the exception of weather satellites, no high-level public policy agenda heralded the appearance of remote sensing. Further, the US government made no long-term funding commitment.

In fact, for the first fifteen years of the space age there were no civil or commercial applications of remote sensing satellites, as the earliest remote sensing satellites were reconnaissance ones used by the US military and the former Soviet Union. In the late 1960s, NASA began the development of an Earth resource satellite and launched the first such satellite in 1972. After NASA's introduction in 1972 of the Landsat series, the first civilian land remote sensing satellites, the seemingly rapid evolution of space imagery applications led space policy-makers in the late 1970s to believe that land remote sensing was ready to be moved out of the federal government to become a profit-making private sector activity.

However, the debate in the US Congress demonstrated that the path to an operational Landsat was not at all clear. Some drew an analogy, not with the telecommunications sector, but with the National Weather Service as a government operation maintained for the public good. The public good versus private profit debate is complicated by the fact that both functions can be evident in the same image; natural resource management and prospecting for oil can be done using the same scene, for example. Also, if this were not confusing enough, several congressional committees claimed jurisdiction over at least some part of Landsat's activities.[10]

The Carter Administration, recognizing the confusion over this issue, initiated a plan to move Landsat operations out of NASA and into the National Oceanic and Atmospheric Administration (NOAA). Carter intended this to be a steppingstone so the satellite system could be gradually privatized.[11] However, Ronald Reagan, whose Administration came to the White House with different ideas about the fate of government programs such as Landsat, replaced Carter in 1981. Carter had been willing to consider the privatization approach for some government programs, but for Reagan it was an ideological imperative. During 1981 to 1984, the Office of Management and Budget (OMB) tended to ignore the significant scientific and foreign relations bonuses that Landsat had obtained and looked to commercialize the program. In support of this position, OMB directed that Landsat operating

costs be recovered by data sales. This led NOAA to increase Landsat data prices (based on the average film price) by 300 percent from 1982 to 1985.[12]

The implication of OMB's policy was that there would be no more government-funded Landsats after the fifth spacecraft, which began operating in 1984. This meant that the system would be terminated if no private operator came forward to assume development and operations costs. Interested members of Congress eventually realized that their disorganization and delay was going to cause them to forfeit decision-making on this matter to the President. So after years of unproductive discussion on the remote sensing issue, Congress passed legislation that would set a commercial course for Landsat and all US land remote sensing efforts for years to come.[13] In this regard, Congress passed the Land Remote Sensing Commercialization Act of 1984 that called for the phased commercialization of Landsat through government subsidies.

The contractor that took over Landsat responsibilities did not fare well because of its inconsistent relationship with the government, and the ineffective and unpopular procedures forced upon it by the 1984 Act, which also discouraged other private firms from entering the market for satellite data. After a bidding process, a collaborative effort between Hughes and RCA called the Earth Observation Satellite Company (Eosat) gained exclusive rights to market Landsat data and continue the satellite series with the help of substantial government subsidies. Eosat won a ten-year government contract in 1985 to market Landsat data. The satellites already in orbit at the time, Landsats 4 and 5, remained government property, but future spacecraft would be owned and operated by Eosat.

The Landsat debate is an illustration of the policy tug-of-war that can emerge between Congress and the Executive Branch that was discussed in the chapter on Presidents and Space Policy. Neither one wanted the other to seize the initiative in setting policies perceived to be important. When the Reagan Administration took over and saw Congress fumbling with the Landsat issue, it moved quickly to include Landsat in its demonstration of a larger agenda, the reduction of big government by shifting of responsibilities to the private sector. Congress responded by passing ill-conceived legislation that was intended to help launch a growing industry, but instead hindered the user community as Landsat data prices rose and anticipated market demand failed to materialize.

No winners emerged from this series of events. Congress, which over time had discussed many scenarios for Landsat operations (e.g., the weather satellite model, and the Comsat and Intelsat models), chose one that did not succeed given the lack of market maturity in civil remote sensing. In the process, the legislature played into the hands of the executive branch. But the President failed to achieve the ultimate goal of removing Landsat from

dependence on taxpayer dollars, since the multi-year subsidies provided by the government were equivalent to the cost of maintaining the system as a government program. The users lost out due to the tremendous increases in data prices, which drove large numbers of researchers and developing country customers out of the market. This was due to increases in average film price first initiated by NOAA in 1982, as mentioned earlier, and then by a further 250% by Eosat from 1985 to 1989.[14] Higher average film prices for Landsat scenes led to a loss of sales that by 1989 film items sold were less than 10% of the items sold in 1985.[15]

To further exacerbate the situation, France launched the first SPOT satellite in 1986. The satellite was operated in such a way as to make it competitive and marketable for the user community. Structured as a public-private partnership, the prices of SPOT data significantly undercut the data prices of Landsats 4 and 5. As a result, users began seeking SPOT data, which further contributed to the demise of Landsat commercialization efforts.

By the early 1990s, even the promoters of the privatization plan had to admit that policy had failed. With renewed interest in environmental monitoring and the high priority assigned to the new US Global Change Research Program, both Congress and the President were prompted to adjust remote sensing policy. Recognizing the failure of Landsat commercialization and desiring to effectively use Landsat to compete with SPOT and other systems coming on-line in other parts of the world, Congress passed the Land Remote Sensing Policy Act of 1992.[16] This Act repealed the 1984 Act, ended Landsat commercialization, and returned the Landsat program back to government control starting with Landsat 7.[17]

Concomitantly, the 1992 Act removed pricing restrictions and data access policies that had hindered the entry and licensing of new remote sensing satellite data providers to the market. During the eight years that the 1984 Act's provisions were in effect, no company saw it fit to apply for a license of entry. Just four months after the 1992 Act's passage, the first license for a private remote sensing satellite system was issued to Worldview Imaging Corporation (now DigitalGlobe).[18] Since then, more than twenty licenses have been approved, and four US satellites are currently (as of 2002) operating. Two of these satellites are operated as a service to the US government (Orbital Sciences Corporation's OrbView-1 and 2) and two are commercial (DigitalGlobe's QuickBird and Space Imaging's Ikonos). In addition, NASA has begun to provide data to commercial vendors from some of its experimental Earth observing satellites for value-adding products. This has precipitated the emergence of the high-resolution commercial remote sensing industry that involves both satellite systems and value-added products.

Despite these developments, the satellite remote sensing market remains underdeveloped worldwide deriving nearly 70% of its revenue in 2001 from government customers, both civil and military.[19] The OrbImage filing for bankruptcy in April of 2002 shows one example of this underdevelopment (OrbImage was the company created by Orbital Sciences Corporation to operate the OrbView satellites). Also, this industry relies heavily on government subsidies in such countries as Canada, Europe, Russia, India, and Israel where competing remote sensing systems and data products exist. Nevertheless, the number of commercial Earth imaging satellites built and launched during the next decade is expected to increase.[20] Success will depend on the timeliness and affordability of images as well as the quality and value-added data products that meet market demands.

Global Navigation Satellite Services

When the US Department of Defense (DOD) first envisioned its global, three-dimensional satellite navigation and precision timing system in the 1960s, no one imagined the extent to which the non-military world would embrace the technology and become dependent on it. Market studies have shown that revenues from Global Positioning System (GPS) related products are a multibillion-dollar industry in North America alone.[21] GPS receivers and augmentations for a multitude of applications have become a lucrative global business, but the market is dependent on satellites and control systems that are funded, operated, and upgraded by the US military. This GPS system began with a series of prototype spacecraft (Block 1) that were launched and tested starting in 1978. The first round of operational satellites (Block 2) began deployment in 1989, and the 24-satellite constellation was completed in 1994, ready to deliver precise position, velocity, and timing data to an unlimited number of users with passive receivers anywhere in the world.[22]

Although designed for the national security sector, US policy recognizes the importance of GPS to the commercial and civil sectors.[23] It is national policy to continue providing GPS service for peaceful civil, commercial, and scientific use on a continuous worldwide basis free of direct user fees. Private sector investment and international cooperation in the use of GPS are encouraged. The policy of the US government is to purchase commercially available GPS products and services that meet its requirements to the fullest extent feasible, and not to conduct activities that preclude or deter commercial GPS activities, except for national security or public safety reasons. Additionally, the government has discontinued the use of Selective Availability, a system function that in the past degraded the accuracy of the satellite signals for non-military users.[24]

A growing market and strong government support would seem to put commercial satellite navigation in a position akin to that of satellite communications in the 1960s, with similar expectations of success. The history of space commerce has shown that one of the key factors in the success of space markets is stable government policy, and GPS policy appears to have developed smoothly and favorably. However, there remain real and potential problems.

Attempts have been made, both domestically and internationally, to encroach on the electromagnetic spectrum reserved for GPS. New and growing communications services seek access to the spectrum, and this could interfere with GPS since communications signals are transmitted at higher power levels. The interested segments of the US government have been fighting to keep this from happening, but some spectrum sharing may be inevitable.[25]

Another concern is that GPS is entirely funded and operated by the DOD, with the exception of specific augmentations for the civil and commercial communities. Despite the existence of the Interagency GPS Executive Board and the active involvement of the Department of Transportation, the DOD must operate the system in a manner that serves its institutional mission, which does not necessarily equate to a nationally accepted vision of GPS as an international public service and economic driver. In the absence of a plan for a GPS architecture driven by commercial (and public good) requirements rather than national security ones, the long-term economic potential of GPS could be adversely affected.[25]

Expendable Launch Services

In the early 1980s, the Space Shuttle fleet began its flight operations. The Space Shuttle was heralded as the first reusable spacecraft, but more significant here is that the Shuttle was the first manned space transportation system to target the private sector as a major market for its services. NASA marketed the Shuttle to all US government and commercial payload customers.

When Richard Nixon announced his approval of the Shuttle program in 1972, he called it "the workhorse of our whole space effort, taking the place of all present launch vehicles except the very smallest and very largest."[27] Throughout the 1970s and early 1980s, this view, known as the "one shuttle launch policy," was reflected in US government space mission planning and in presidential policy.[28] This led to policy that called for a

phasing out of governmental support for expendable launch vehicle (ELV) programs.

The Reagan Administration's general belief in the superiority of private-sector products and services opened a window of opportunity for commercial entities interested in marketing the government's existing Delta, Atlas, and Titan ELVs. If these ELVs were terminated in favor of the Space Shuttle, which was in fact the policy from 1981 to 1986, a gap in launch services could arise due to the need to redesign satellite deployment systems for the Shuttle cargo bay, uncertainties about unproven Shuttle capability, and the availability and pricing of the Space Shuttle. The Challenger accident and the grounding of the Space Shuttle fleet for three years realized this scenario of a gap in launch services and precipitated changes in national space transportation policy. Meanwhile, the Ariane ELV, built by a consortium of European interests led by France, had begun operations and had seized a majority market share for commercial launches.

This situation encouraged executive and legislative interests in privatization of the government's ELV fleet, and the licensing and regulation of commercial ELVs. Representatives from industry, big aerospace corporations to small start-up companies, sought to establish a regulatory regime for licensing private launches that would be streamlined and flexible. After considerable lobbying and interagency competition, this was achieved when President Reagan assigned the Department of Transportation as the lead agency for providing licensing and regulation for private-sector space launches.[29] This was soon followed by legislation that codified this choice of lead agency and authorized the privatization of the nation's ELV fleets.[30]

In space commerce, the quest continues for affordable, reliable, frequent, and flexible access to space. Access to space remains a difficult challenge, demonstrating the slowest rate of improvement of all space technologies. Table 11.1 documents this fact, showing that costs per Kg to LEO, across all types of launch capacity classifications, ranges from $3500 to as high as the tens of thousands of dollars.

Table 11.1. Commercial Launch Vehicle LEO Pricing Comparisons.
Source: Futron Corporation, 2002.

Vehicle Name	Country	LEO Capacity (Kg)	Launch Price (2000 US$ M)	Cost per Kg (2000 US$)
Small				
Athena 1	USA	800	16.5	20,625
Athena 2	USA	1,990	24.0	12,060
Cosmos	Russia	1,400	13.0	9,286
Pegasus XL	USA	443	13.5	30,474
Rockot	Russia	1,850	13.5	7,297
Shavit	Israel	160	13.5	84,375
VLS	Brazil	380	8.0	21,053
Medium				
Cyclone 3	Russia	4,100	22.5	5,488
Delta 2 (7420)	USA	3,201	50.0	15,620
Delta 2 (7920)	USA	5,144	55.0	10,692
Dnepr	Russia	4,400	15.0	3,409
Long March 2D	China	3,500	12.5	3,571
Long March 3	China	5,000	37.5	7,500
Long March 4	China	4,000	25.0	6,250
PSLV	India	2,900	20.0	6,897
Titan 2	USA	3,583	35.0	9,768
Intermediate				
Ariane 42L	Europe	6,883	90.0	13,076
Ariane 44L	Europe	10,200	112.5	11,029
Atlas 3A	USA	8,640	97.5	11,285
Atlas 5 552	USA	20,520	75.0	3,655
Delta 4 Medium Plus (4,2)	USA	10,430	75.0	7,191
Delta 4 Medium Plus (5,2)	USA	7,980	75.0	9,398
GSLV	India	5,000	35.0	7,000
H 2A 212	Japan	17,280	64.0	3,704
Long March 2E	China	9,200	50.0	5,435
Long March 3A	China	7,200	50.0	6,944
Soyuz	Russia	7,000	37.0	5,357
Heavy				
Ariane 5G	Europe	18,000	165.0	9,167
Delta 4 Heavy	USA	23,040	160.0	6,944
Long March 3B	China	13,600	60.0	4,412
Proton	Russia	19,760	85.0	4,302
Space Shuttle	USA	28,803	300.0	10,416
Titan 4B	USA	21,701	400.0	18,432
Zenit 2	Ukraine	13,740	42.5	3,093
Zenit 3SL	Multinational	15,876	85.0	5,354

Since space access has an overwhelming influence on all aspects of civil, commercial, and national security space efforts, the government retains some of the responsibility for addressing this problem of launch costs. The private sector also has the technical capability to contribute solutions, such as with low cost ELVs and the development of reusable launch vehicles (RLVs). However, the private sector cannot be confident that they will get back what they have invested within a reasonable timeframe– a return on investment (ROI)– so the sector often looks to the government to share the technological and capital risks.

Figure 11.1 below graphs how this public-private relationship is possible; the government plays a role in capital formation for developing space technology, thus reducing risk and enhancing possibilities for ROI for the corporate entity that commercializes the technology. The need for public-private partnerships in the US is also reinforced given overseas competition from Europe's Ariane, Russian ELVs, China's Long-March, and the emerging ELV efforts of Japan and India where substantial government support is provided. A number of these foreign launch vehicles are listed in Table 11.1.

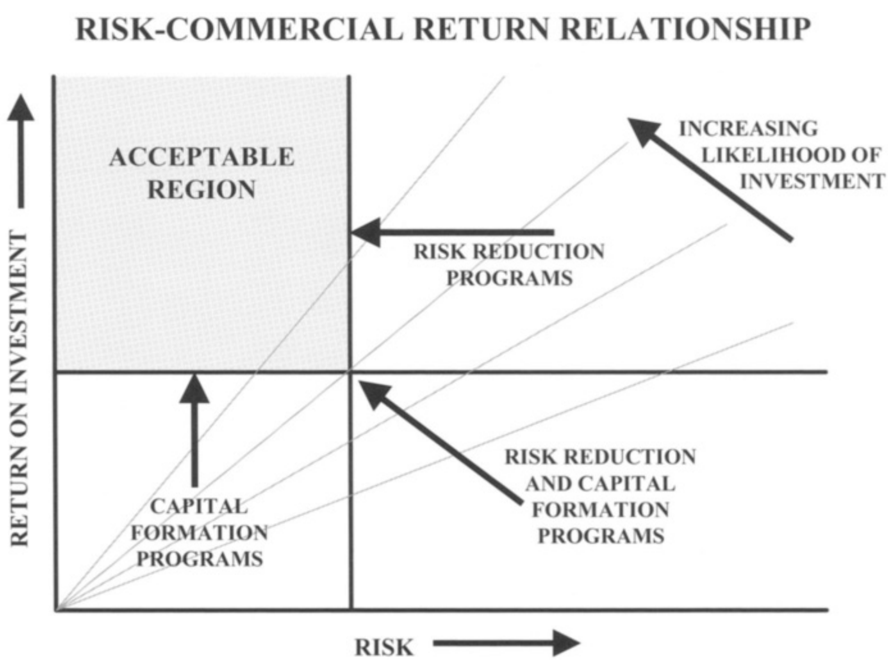

Figure 11.1. Risk-Commercial Return on Investment Relationship.

In 1994, the Clinton Administration put forward a national space transportation policy that continues to set the way in which space transportation commerce is pursued by the US government.[31] NASA has been given policy domain over the development of RLVs and single-stage-to-orbit (SSTO) technologies, while the US Air Force was given responsibility for ELVs and is pursuing evolved ELV (EELV) technology development. The intent is to develop these launch vehicle technologies on the basis of the public-private partnership as shown in Figure 11.1, and in such a way that the technologies serve the interests and requirements of both governmental and commercial space sectors.

Concomitantly, this approach to space technology development and commercialization raises a number of concerns that need to be addressed. This includes issues of: government competition with the commercial sector; market implications of having the government as the primary customer; financial and tax laws, and incentives for developing and commercializing new space technology; governmental contracts that serve as an incentive for the aerospace industry to maintain the status-quo as listed in Table 11.1; scales of economies and political barriers for space commerce development; the proper roles for NASA and the US military in fostering space commerce; lack of financing in both the public and private sector; and conflicts of interest between the governmental and commercial space sectors.

EVOLUTION OF COMMERCIAL SPACE POLICY

Policy statements encouraging commercial space development began appearing in the Carter Administration,[32] but the first real attempts at a comprehensive US government policy toward space commerce came in the 1980s. This was driven by technology maturation, market demand for satellite communications and launch services, and expectations of profits in new areas such as remote sensing and materials processing. Policies addressing different segments of the commercial space sector have already been discussed, but the Reagan Administration's 1988 National Space Policy[33] was the first presidential directive to recognize space commerce as a distinct sector of space activity and to establish guidelines for supporting it. The Bush (89)[34] and Clinton[35] Administrations later adopted much of the same wording, with minor embellishments.

The essential elements of presidential guidance since the late 1980s direct the US government to: support and enhance US economic competitiveness in space activities; purchase commercially available space goods and services to the fullest extent feasible; refrain from activities with

commercial applications that preclude or deter commercial space activities, except for reasons of national security or public safety; pursue commercial space objectives without the use of direct federal subsidies; supervise or regulate commercial space activities only to the extent required by law, national security, international obligations, and public safety; facilitate commercial-sector access to US government space-related hardware, facilities, and data; enter into appropriate cooperative agreements while protecting the commercial value of intellectual property; identify portions of US laws and regulations that unnecessarily impede the commercial space sector, and propose amendments or elimination; provide for timely transfer of government-developed space technology to the private sector, including protection of its commercial value and retention of data rights by the private sector; and support trade policies that encourage a competitive international environment for space commerce.

Many of these ideas were codified into congressional law with the passage of the Commercial Space Act of 1998, Public Law 105-303. This act calls for the US government to encourage the development of a commercial space industry in a number areas ranging from the commercialization of the International Space Station (ISS); removal of barriers to applications of GPS; treatment and acquisition of space science data as a commercial item; and requirements for governmental procurement of commercial space transportation services. In response to this Act, NASA has developed plans for commercializing ISS and strategies for developing space commerce.[36]

The long-term viability of the space commercial sector depends on the consistent application of these policies by US governmental agencies, primarily NASA, DOD, and the Departments of State, Commerce, and Transportation. There are many opportunities for these policies to run afoul of governmental objectives. For example, Defense or State may block industry-preferred trade policies if they sense a potential threat to US security or foreign policy interests; agencies may find numerous excuses as to why commercially available space technologies will not fulfill government requirements; and intellectual property may be difficult to protect if an agency is required to disclose it under a Freedom of Information Act request. Additionally, governmental agencies cannot take actions that cost money unless the funding is available and Congress has no objections. Presidential and congressional policies on space commerce are a necessary step in the evolution of the US commercial space sector, but are not sufficient to guarantee long-term success. Bold ideas and their execution are left to others in the space community, and agreement on goals and objectives is often hard to achieve.

Role of Government

A significant shift took place in the space community in 1997, both in the US and worldwide. For the first time, private sector space revenues exceeded government space expenditures, and the number of commercial payloads launched into space exceeded the number of government payloads.[37] This trend is expected to continue, increasing the private-sector share of global space activity for the foreseeable future. What does this portend for the government's role in the coming years?

US policy toward commercial space is linked to the debate over technology policy, or more generally, industrial policy. This debate has raged since the end of World War II, when the government became a dominant player in the nation's R&D efforts. Should the government be involved in promoting particular industrial sectors; and if so, how much and by what means? If such involvement benefits society (i.e., produces a "public good" such as weather forecasting), it would seem to be a worthwhile investment of taxpayer money. But there is no guarantee that the government will routinely make the best choices about where to invest. Bad choices can sink large sums of public money into efforts that produce no benefits at all, or which give an unfair advantage to a select group of profit-seekers in the private sector.

On the other hand, there is no guarantee that market forces will lead to the best investment choices, at least where societal benefits are concerned. Advances in technologies and processes often have high risks, high costs, and long lead times. Even where profitability seems likely in the long-term, private sector entities are disinclined to risk their near-term health on long-term probabilities, especially when they are unlikely to capture all the resulting benefits of their investments and an acceptable ROI.

Governments in industrialized countries have demonstrated that they can be successful in four traditional roles: fund and even perform R&D that is likely to be underfunded by the private sector; establish and encourage the building of infrastructure, such as roads, railroads, airports, and harbors; become an early adopter of new products and services, helping to stimulate the initial market; and enact and enforce regulations in areas such as environmental protection, worker safety, and consumer protection.

History has taught that governments are most often unsuccessful at "picking winners" for commercial competition.[38] But if US policy calls for encouragement of space commerce, then the government must pick something. The methods by which the government could aid space commerce are many and diverse: targeted research programs, direct subsidies, patent licensing, regulatory or anti-trust relief, tax breaks, low-interest loans or loan

guarantees, provision of infrastructure, guaranteed government purchases, and liability indemnification.

Unfortunately, space development, along with other technology and trade issues, gets mired in political debates and disagreements on the amount and type of government intervention. This is only compounded by the issue of space commerce and national security concerns. The results are policies that are uncoordinated with each other and inconsistent over time. For the space industry, this is particularly unwelcome in a period when space capabilities and marketing aggressiveness of international competitors are growing.

SPACE COMMERCE AND NATIONAL SECURITY

An examination of the list of technologies required for commercial space projects reveals that nearly all of them are "dual use." In other words, they are applicable to both commercial and national security space systems. A number of technologies are essential for both of these space sectors, including, for example, sensors, propulsion, guidance, satellite control, space-rated electronics, encrypted communication links, and antenna design. Since space businesses are global in both their markets and supplier relationships, conflicts emerge among government agencies responsible for overseeing the contradictory policies toward the promotion of international trade and the protection of militarily significant technologies. Two recent areas of concern in this regard are remote sensing technologies and the exporting of satellite component technologies.

Remote Sensing and Shutter Control

An important case of space commerce and national security issues exists with satellite based remote sensing. Since the emergence of commercial uses of remote sensing, resolution limitations imposed to protect national security have lessened. In the late 1970s, the Carter Administration lowered the spatial resolution limit on non-military systems to ten meters.[39] After Congress passed the Land Remote Sensing Policy Act of 1992 directed to end the federal monopoly on remote sensing technology and data distribution, numerous commercial interests began to apply for remote sensing satellite licenses and lobbied for lower spatial resolution restrictions.[40] In response, the Clinton Administration put forward Presidential Decision Directive-23 (PDD-23) to give guidance on the licensing of commercial remote sensing satellites. PDD-23 removed spatial resolution restrictions on

commercial remote sensing satellites, making the resolution limit a decision to be made by the authority licensing the system on a case-by-case basis.[41] This stands in stark contrast to the previous national security protection elements of imposing spatial resolution limits and access to remotely sensed data.[42]

PDD-23 contains language that is of concern for economic imperatives and commercial interests. The most controversial requirement is commonly referred to as shutter control–

> During periods when national security [defense and intelligence] or international obligations and/or foreign policies may be compromised, as defined by the Secretary of Defense or the Secretary of State, respectively, the Secretary of Commerce may, after consultation with the appropriate agency, require the licensee to limit data collection and/or distribution by the system to the extent necessitated by the given situation. Decisions to impose such limits only will be made by the Secretary of Commerce in consultation with the Secretary of Defense or the Secretary of State, as appropriate. Disagreements between Cabinet Secretaries may be appealed to the President. The Secretaries of State, Defense, and Commerce shall develop their own internal mechanisms to enable them to carry out their statutory responsibilities.[43]

Efforts have been made to make it clear when shutter control might be implemented and how it would work. However, it is not yet entirely clear how significant the impact of shutter control might be on the commercial sector.

Shutter control use by the US government began in 1996 when the Israeli government petitioned the Clinton Administration to restrict US commercial remote sensing of their territory to resolutions no better than three meters.[44] The argument for this was based on the fact that the sale of high-resolution satellite imagery could jeopardize Israel's physical security if its neighbors gained access to the imagery. This led to a congressional amendment to the fiscal year 1997 Defense Authorization Act on behalf of Israel regarding satellite imaging of the state and its territories.[45] Known as the Kyl-Bingaman Act it states:

> …Collection and Dissemination. A department or agency of the United States may issue a license for the collection or dissemination by a non-Federal entity of satellite imagery with respect to Israel only if such imagery is no more detailed or precise than satellite imagery of Israel that is available from commercial sources.

> …Declassification and Release. A department or agency of the United States may declassify or otherwise release satellite imagery with respect to Israel only if such imagery is no more detailed or precise than satellite imagery of Israel that is available from commercial sources.[46]

The Departments of Commerce and State announced that this means a ban on distribution of images of Israel with a resolution less than two meters.[47] In order to obtain an operating license, a commercial operator must submit a plan explaining how its system will comply with the Kyl-Bingaman restrictions. Violations of the ban on high-resolution imagery of Israel are punishable by fines up to loss of the operating license. Israel remains the only nation over whom these restrictions are currently imposed, but in the future the US may be faced with the choice of either abolishing the policy or extending it to other states.

There are problems with the Kyl-Bingaman Act, as there are numerous aerial and satellite imagery providers offering two meter or better resolution of Israel to anyone, including Israel's neighbors.[48] Additionally, an Israeli-led company, ImageSat International, has launched Eros-Al, a commercial remote sensing satellite with a standard image resolution of 1.8 meter and an over-sampled resolution of one meter.

Shutter control has continuously been debated since PDD-23. In an attempt to further clarify when and how shutter control might be implemented, the Department of Commerce signed a Memorandum of Understanding (MOU) with the Departments of State, Defense, and Interior, and the Intelligence Community as to how they would work together during the licensing process to make certain that all the elements of national security are taken into consideration. The MOU discussed when and how shutter control restrictions could be placed upon a system. In response to the concern of satellite operators, the MOU makes the shutter control decision one that occurs at the highest levels of the respective governmental departments. If they cannot agree, then the issue is sent to the President for a decision. Attempting to clarify when shutter control might occur, the MOU states that:

> Conditions should be imposed for the smallest area and for the shortest period necessary to protect national security [defense and intelligence], international obligations, or foreign policy concerns at issue. Alternatives to prohibitions on collection and/or distribution shall be considered such as delaying the transmission or distribution of data, restricting the field of view of the system, encryption of the data if available, or other means to control the use of the data.[49]

In the aftermath of 11 September 2001 and during military operations in Afghanistan, the US opted not to exercise shutter control as specifically described in PDD-23 and the MOU. However, the US government has made use of alternative means to control the use of remotely sensed data. Beginning in October 2001, the National Imagery and Mapping Agency (NIMA) signed a contract with Space Imaging, whose Ikonos satellite was the only US commercial high-resolution satellite operating at the time, for the exclusive rights to satellite imagery collected over Afghanistan and the surrounding areas. This set a policy precedent for how to control data distribution from US commercial operators and data providers, albeit via methods other than what has been considered shutter control.

Since then, this alternate approach to get at shutter control is less of a viable policy. During the blackout on the distribution of high-resolution Ikonos data to others besides the US Intelligence Community, ImageSat International sold high-resolution imagery to news media and other organizations on the open market. Moreover, US war efforts in Afghanistan and other areas have continued, while DigitalGlobe's 0.61m resolution QuickBird satellite began operating and NIMA discontinued the imagery buyout of Ikonos data.

Satellite Export Controls

Recent treatment of satellite export control is an example of how national security policies can have substantial economic consequences. In the early 1990s, as the Cold War subsided, the Bush (89) Administration began easing controls on certain technological products and components. The Clinton Administration continued this process and in 1996 moved export-licensing jurisdiction over commercial satellites and components from the Department of State to the Department of Commerce. Over the next two years concerns emerged over the alleged transfer of sensitive technologies to China, and Congress assigned much of the blame to the practice of allowing US manufactured commercial satellites to be launched on Chinese rockets.[50] Congressional desire to take visible action against the perceived Chinese threat resulted in the transfer of satellite export authority back to the State Department starting in 1999.[51] This move proved to be ill conceived. The State Department, which neither sought nor welcomed the change in jurisdiction, was not equipped to handle the large volume of export applications for satellites, components, and technical assistance agreements, and Congress initially did not provide any funding for the task.

In addition, this action placed satellites on the munitions list, which is governed by the International Traffic in Arms Regulations (ITAR). Under the ITAR regime, satellites and their components, including technologies to allow a US built satellite to launch on a foreign rocket, were treated the same as weapon systems. The slowdown this caused in the export license application process, and the uncertainty it generated in the minds of customers around the world, were alleged by industry analysts to be the primary cause of a drop in US satellite market share, reversing a growth trend in previous years. Foreign firms and governments reportedly backed away from satellite deals, and a number of nations informed the US Secretary of State that they would seek non-US sources for satellite parts due to the new export policy.

The satellite export case is one of many that illustrate the continued strong influence of politics over the success of US entrants in high-technology global markets. It also highlights the importance of bureaucratic handling of licensing and regulatory duties. In this case, the Departments of State and Commerce had different motivations for their treatment of license applications. Commerce gives high priority to the promotion of fair trade in US goods and services, with an eye toward safeguarding critical technologies. State, on the other hand, puts foreign policy issues first, and would not hesitate to risk US market share if it believes that doing so would achieve a foreign policy goal.

In today's world, the rapid rate of technology diffusion, the increasing number and absorptive capacity of technology recipients, and the wide array of transfer mechanisms indicate that those responsible for restricting access to space technologies face a chronic problem. The US is not the sole source for most of these technologies, so national policies attempting to unreasonably stifle their dissemination will result in lost US market share. This leads to a weakened US space industrial base, increased sales for foreign competitors, and possibly an increased number of foreign competitors. The satellite export case shows that actions taken to bolster national security undermine US leadership in important economic sectors such as the satellite industry.

LONG-TERM SPACE COMMERCE TRENDS

Multinational Business Collaborations

One way to gain access to growing global markets is to establish strategic partnerships with key companies around the world. Such partnerships can also quickly expand a product line to serve a wider range of users. This strategy has been pursued to varying degrees in all commercial space sectors. In launch services, the Ariane rocket is owned and operated by

a consortium of European interests; Boeing has joined forces with Russian, Ukrainian, and Norwegian companies in the Sea Launch venture; Lockheed-Martin is teamed with Russian enterprises Khrunichev and Energia to provide Proton launches; and Russian and German companies together are offering the Rockot small launcher. In satellite manufacturing, the teaming of European and US companies is becoming common. Remote sensing companies have regional affiliates around the world both for marketing and for direct downlinking of imagery. In satellite communications, international alliances often involve equity stakes among the partners in the project to achieve regional and global connectivity. The partners provide a gateway to the local communications infrastructure and handle the marketing, billing, taxes, and regulatory matters for their area. Under this arrangement, the company has a presence in each major market and appeases local concerns about compliance with regulations and taxation.

Policy concerns for such arrangements can arise from responsibilities specified in multilateral space treaties. If the national affiliation of a space system operator is unclear, which nation will ensure that launches and payloads are recorded with the United Nations as specified by the Registration Convention?[52] Which sovereign state will assume responsibility under the Liability Convention[53] if a third party suffers damage due to a launch mishap? In addition, technology transfer concerns could appear on the policy agendas if US government relationships with partner countries change, there are perceived threats to national security, or interest groups, such as the "Business in Space" advocacy coalition, complain about unfair foreign competition and trade practices. Space commerce is a global business, so the international alliances and the policy and legal issues they generate can be expected to persist.

Public-Private Partnerships

Mechanisms have existed for some time in many parts of the government to encourage business development. Some of these mechanisms are being used today for the benefit of commercial space ventures. For example, NASA has been chartered since its inception to transfer technology to non-government sectors. It has done this through publications (e.g., NASA Tech Briefs), distribution centers (e.g., Regional Technology Transfer Centers), technology transfer offices at its field centers, special programs such as the Commercial Remote Sensing Program, and the Centers for the Commercial Development of Space. Such programs split the cost of

development between the government and private sector, and provide incentives such as access to government facilities.

The size and scope of space-related partnerships has expanded in recent years. Some prime examples are the development of the X-33 SSTO RLV, intended to be a demonstrator for an eventual commercial vehicle of what was called Venture Star, and the EELV program. Even though the X-33 effort failed due to technological issues, it did demonstrate that the government can play a role in developing technology for commercial use. The development of the EELV program undertaken by the US Air Force is intended to achieve the heavy lift capacity needed by the military, while allowing for the "next generation" commercial ELV to be developed by US companies (Boeing and Lockheed-Martin). Whether these approaches to commercial development space transportation will work out is uncertain, as the pursuit of one technological goal that can meet the interests of both the government and commercial sectors is problematic.

In the market for remote sensing data, there has been a recent trend, largely due to the urging of Congress, for government agencies to purchase data commercially rather than develop their own satellite projects. This has been focused primarily on NASA's Earth Science Enterprise and DOD's mapping and surveillance needs. US government guaranteed purchases of data has allowed a commercial remote sensing industry to develop; as mentioned earlier, 70% of the industry's revenue as of 2002 is from the government. Such "anchor customer" arrangements, however, will likely be of limited duration; the setting aside of congressionally appropriated funds for the purpose of stimulating nascent industry efforts, while hopefully saving the government money on the procurement and operation of satellite systems could prevent market maturity and impede further commercialization in remote sensing.

FUTURE SPACE COMMERCIAL SECTORS

Considerable space commercial activity already exists in satellite telecommunications, remote sensing, GPS, and ELVs. Figure 11.2 graphs the growing commercial activity in these areas, which has approached $100 billion in worldwide revenues. There are also a number of potential future space business sectors. This includes RLVs discussed earlier and others such as microgravity materials processing and manufacturing, space solar power (SSP), space tourism, space mining and resource development, orbital debris removal, space rescue, and space servicing and transfer. Several of these future sectors are briefly discussed herein including microgravity materials processing and manufacturing, SSP, and space tourism.

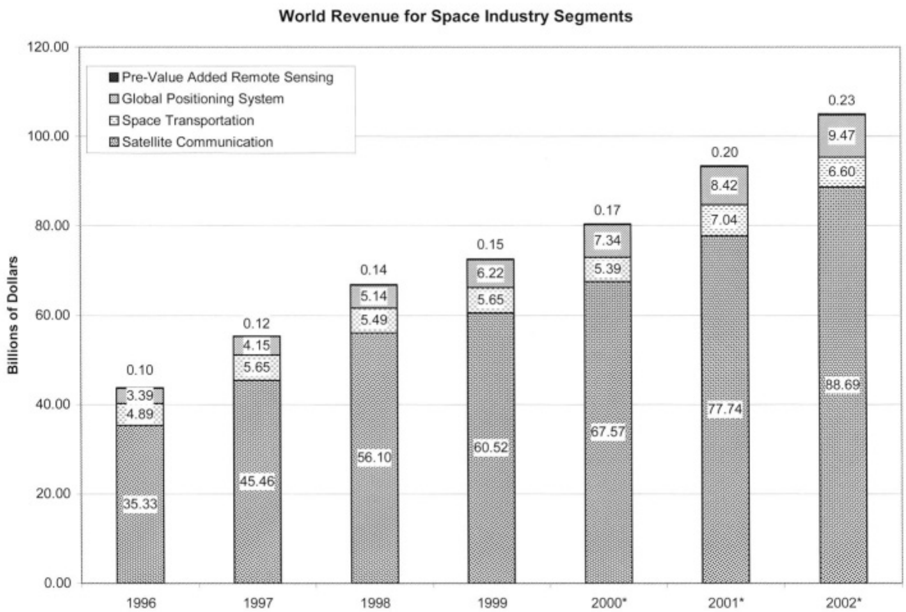

Figure 11.2. World Revenue for Space Industry Segments.
*Note: *Estimates*
Source: Trends in Space Commerce, US Department of Commerce, Office of Space Commercialization, 2000.

Microgravity Materials Processing and Manufacturing

Ever since experiments were performed aboard the Skylab missions in the early 1970s, researchers from several disciplines have been intrigued by the possibilities of using the unique environment of space to study and process materials. Among the applications touted are new metal alloys with special properties, purer Pharmaceuticals, and better crystalline and ceramic structures. In addition to applied research, basic research on the structure and behavior of matter might be more efficient in orbit, where microgravity could reveal previously unknown characteristics in materials that will allow advances in Earth

The advent of the Space Shuttle raised hopes that large-scale production of profitable materials was just a few years away. It was hoped that the Shuttle would serve as a space laboratory with materials science experiments ushering in a new sector of profitable space commerce by the end of the 1980s. Several factors, however, foiled this notion.

The Shuttle did not fly as often as advertised, and only occasionally carried a full laboratory, so many experiments were limited to the space available in the Shuttle mid-deck lockers. Even these experiments were expensive to prepare and took a long time to get onto the cargo manifest. Many researchers opted for cheaper, more flexible terrestrial alternatives that would allow them to repeat experiments as needed rather than wait years for an opportunity in space. Materials processing efforts lack affordable, frequent, flexible access to space and remain in the basic research stage. The hype of near-term profits faded long ago, as the community awaits better conditions for applied research and product development on orbit.

To date, no marketable products have resulted from this work. Given the current cost of access to space, any economically viable product would have to be of high value and low volume. These conditions are unlikely to change in the near term, but full operation of the ISS could pave the way for commercialization in this area as is called for in Commercial Space Act of 1998 and in NASA's commercial development plans for ISS.

Space Solar Power

The SSP concept, in which large orbiting arrays of solar power satellites would gather solar energy and transmit it to power grids on Earth, was assessed from 1975 to 1980 by NASA and the US Department of Energy. The results of the assessments identified no single constraint for SSP development for either technical, economic, environmental, or societal reasons.[54] However, as a result of economic viability issues and political opposition by oil companies, environmentalists, anti-technologists, and other competitors for public funding, the SSP concept did not reemerge on the political agenda until the mid-1990s.

Technical advances, environmental concerns, and growth projections for energy demand[55] have reawakened interest in SSP in recent years. Two decades of further development and experience with space systems, since the SSP assessments of the 1970s, have shown that there are many possible system designs, some of which might attract near-term investment from the private sector. This became evident in NASA's "Fresh Look" study of 1997, which examined different SSP concepts. The study's objective was to define system architectures with the potential to deliver cost-competitive electrical power to terrestrial markets without major environmental drawbacks.[56]

The emergence of SSP displays some of the same characteristics enjoyed by satellite communications forty years ago. Demand for the product is practically universal; the physical and regulatory ground-based energy infrastructure is largely in place; and countries with growing needs can jump

ahead in technological evolution. In the near-term, nonetheless, SSP is unlikely to move beyond the public policy agenda as the political momentum and financial backing, like that that stimulated the rapid success of satellite communications, are lacking. Additionally, assessments undertaken of SSP economic viability have shown that energy production per kilowatt is not yet competitive with terrestrial energy production prices.[57]

Even though SSP is not yet ready for deployment, it does have potential to be an important addition to the global energy infrastructure that addresses clear and present energy needs, while at the same time generating economic benefits.[58] SSP represents a new space-based capability that is important for industrialized nations, which are being asked to curtail emissions of carbon dioxide and other pollutants, and for developing nations, which may be able to employ SSP to leapfrog the energy generation technologies that are responsible for a significant portion of harmful emissions and other types of environmental pollution.

Will environmental concerns be sufficient to rally the necessary support? So far, the expectation of a rise in the Earth's average temperature over the next hundred years has failed to generate enough political concern to warrant support of SSP. If SSP is to generate sufficient impetus, it will have to be more than a possible solution to a long-term problem of global climatic change. The problem will need to be defined and communicated more clearly, and SSP will need to be convincingly portrayed as an important and profitable part of the solution.

Policy-makers would be inclined to embrace SSP if they saw it as good for a significant portion of society, but unable to succeed in a timely manner without government help, and therefore worthy of public funding despite the obvious potential for private profit. There are pockets of support for SSP in political circles around the world, but so far such support falls short of the critical mass needed to place it firmly on the policy agenda so that the issue could move forward to policy formulation and implementation.

Space Tourism

Closely linked to the development of next-generation space launch capabilities is the prospect for routine trips into space by non-astronauts. If human-rated space launches can be made more frequent, reliable, comfortable, and affordable, through the development of RLVs, for example, then a large market could develop for passenger trips to orbit.[59] At least initially, significant numbers of people would make the excursion just for the experience of space travel and the chance to look back at the Earth from

space. Eventually, one can imagine a competitive market for off-world resorts in orbit or on the lunar surface. Potentially, there is a market demand for space tourism at ticket prices for a ride in space ranging from $25 thousand to $3 million.[60]

While some foresee space tourism beginning in the near-term, it is more realistic to acknowledge that for some time, the "tourists" going into space will be few in number and must be willing to take great risk and pay a very high price (i.e., hundreds of thousands to millions of dollars for a trip to orbit). One space tourism company, Space Adventures, offers the possibility of a ride on the Russian Soyuz spacecraft to the ISS for $20 million dollars,[61] and is also taking reservations, at ticket process of about $100 thousand, for suborbital flights on a future RLV.[62] In April 2001, Space Adventures assisted with and facilitated the flight to the ISS of the world's first space tourist, Dennis Tito.

Public policy will also play an active role. In July of 2001, a Space Tourism Promotion Act was introduced in the US House of Representatives. The introduction of this Act indicates that space tourism has moved high enough on the policy agenda as to be considered for legislative action on the part of the government. This Act recognizes the potential of a viable space tourism market place and calls for the Department of Commerce to foster growth in this area by putting in place a regulatory structure and financial incentives, such as guaranteed loans and tax credits to space tourism companies.

The regulatory structure necessary to ensure the safety of space tourism will need to certify space passenger liners in a manner similar to airliners, and space traffic control will become a concern, at least in the launch and reentry phases. Spaceports will face the same public safety and environmental issues as do airports today. None of these hurdles are insurmountable, but collectively they will consume considerable time and effort in the policy-making and legislative processes, and they represent important factors that space tourism companies will need to consider as they develop and implement their business plans.

CONCLUSIONS

US government policy-making on the commercial development of space has been at times inconsistent, ineffective, counterproductive, and partisan. Private sector interests often have had to deal with indecision, delay, and reversals in policies affecting their business plans. Yet there have been successes, the most notable being satellite communications. Some have lamented the slow pace of space development and suggested that the

government end its efforts (other than basic science) and let the more efficient, market-driven private sector take over. This raises a number of questions.

If the current pace of space development is considered slow, what is it being compared to? The aviation industry is a typical choice; the industry went from the invention of the airplane to the first transoceanic passenger flights in less than four decades. It has been more than four decades since the first human spaceflight, yet we have no routine passenger flights to the Moon, or even to Earth orbit. Such arguments, however, are unsupportable, since space operations cannot be expected to follow similar development schedules as terrestrial operations due to their higher degree of technical difficulty and risk. Indeed, even the various activities within the rubric of space commerce-space transportation, communications, remote sensing, and navigation-evolve technologically and operationally at vastly different rates.

The suggestion that a government exodus from space development would open the floodgates of private investment is similarly unrealistic. At this point in time, the private sector has shown no indication that it is willing to independently fund and operate all the spaceports, launchers, tracking systems, space platforms, and R&D labs necessary to maintain the current level of commercial space activity, let alone drive expansive dreams of space profits in the new business sectors mentioned earlier.

The success of US policy on space commerce lies in finding the proper blend of efforts between the government and private sectors. Each has its own strengths to offer. The government traditionally has been successful at performing and funding basic research (e.g., in NASA labs and at universities), being an early adopter of new capabilities (e.g., airmail service), building infrastructure (e.g., roads, seaports, launch facilities), and regulating health, safety, and consumer protection. The private sector has its strengths in developing and marketing products and services for a wide community of users. Commerce relies on reducing risk (both in capital formation and technological development) and maximizing RO1. Governmental space policy, if it is to promote space commerce, will need to fashion a role in the space market place that allows for the risk-ROI calculus to be realized for industry.

The path to successful space development is not a black-and-white choice between the government and private sectors, nor can the timetable be accurately determined. As space commerce continues its growth, policy-makers will be forced to become savvy about its effect on, and importance to, their constituents. Hopefully, this will result in better policies in an area that is more difficult, more time-consuming, more costly, and potentially more lucrative than other business sectors.

12
Ethics and Off-Earth Commerce

David M. Livingston*

INTRODUCTION

Corporate responsibility involving ethical issues and industry standards has become increasingly important in business, political, societal, and policy-making environments. Because of the recent Enron, Global Crossing, Arthur Anderson, and WorldCom bankruptcies and scandals, legally mandating ethical behavior in both the corporate and political worlds is part of the political discourse. As such, it is appropriate for the commercial space industry to take note of the increasing importance of ethical corporate behavior and responsibility.

The commercial space industry has both the advantage and the opportunity to learn from the problems and mistakes made here on Earth regarding ethical issues; the consequences resulting from the lack of corporate responsibility and the related public policy issues and management behavior. Learning from these problems and mistakes allows for the development of a code of ethics and standards that strive to assure that space commerce will evolve ethically and responsibly. Although advanced and mature space commercialization in areas other than telecommunications still lie in the future, developing guidelines for corporate ethics and business practices are appropriate topics for business leaders and policy-makers. This formative period in space commerce provides a unique opportunity to consider a code of ethics, and the public policies and planning mechanisms that will ensure effective standards for future corporate conduct and policy in space commerce.

Currently, exploration of space has prepared the way for commercial development and opportunities off-Earth in Earth orbit, on the Moon, and even Mars and beyond. The exploration of these new realms calls for the adoption of new and more accurate terminology. Previous references to off-Earth development have included space, outer-space, off-world, and off-planet. Each of these designations are lacking in conveying the scope of this new undertaking to the general public, whose support is essential. While space is the accepted term for the areas explored by NASA and other institutions, the terms "off-world" and "off-planet" are inaccurate descriptors

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for the commercial expansion because this expansion includes other worlds and planets. The term "off-Earth" provides the accuracy needed for properly describing the extension of corporate ethics here on Earth to that of commercial space development; off-Earth commercial and policy development is a natural extension of societal evolution since what we do here on Earth follows us as we move off this planet in future generations.

Off-Earth economic expansion will come into existence faster, with far more acceptance from concerned people and with more profit potential, when it follows successful ethical models prevalent in modern business. Some well-known examples of national businesses that have grown and prospered as a result of their ethical approach include the retail giant Nordstrom, Ben and Jerry's, Whole Foods Market, and The Men's Wearhouse. There is no shortage of investment counselors and funds whose job is to search out ethical companies that represent attractive investment opportunities. Companies, aware of an increasing demand for responsible and ethical business operations, even use ethical approaches in their advertising and marketing campaigns because they know that this approach to business attracts customers.

The idea of following an ethical approach to carrying out business is no longer new or unique; ethics are currently taught in marketing classes and referenced in business textbooks. *Essentials of Marketing* points out that from 1995 to 2000 the number of large companies appointing ethics officers has grown from none to about 25% of large corporations, that about 60% of companies surveyed had a code of ethics, and that a third of the companies offered ethics training.[1] It is also worth noting that there are companies involved in the aerospace industry that have a code of ethics, including Boeing and Hewlett-Packard.

A number of advantages to the company and employees have been identified in the use of ethical guidelines for the conduct of business.

> It helps employees identify what their firm recognizes as acceptable business practices. A code of ethics can be an effective internal control on behavior which is more desirable than external controls like government regulation. A written code helps employees avoid confusion when determining whether their decisions are ethical. The process of formulating the code of ethics facilitates discussion among employees about what is right and wrong and ultimately creates better decisions.[2]

It is clear that developing space commerce in an ethical manner is profitable. There are successful companies making ethics a priority in their business

operations. It is possible to employ this practical and necessary ideal leading to a code of ethics for business development off-Earth.

WHAT IS A CODE OF ETHICS

A code of ethics facilitates the work and expansion of individual businesses, rather than hinder their efforts toward providing products and services. This ensures the development of space commerce unfettered by government-created barriers. One of the inherent risks facing expansion of the commercial space industry is that if the industry does not develop effective and supportive professional codes of ethics and standards, then government imposed regulations and laws will fill the void. Should this occur, the creation of new barriers to space commerce are likely rendering future development far more difficult and costly.

The evolution of a code of ethics involves input from those in business advocating and planning commercial space ventures, as well as the appropriate public sector policy-makers. Consideration of ethics shifts decision-makers to think beyond the return on investment or technical concerns. The extension of ethics used within the terrestrial business community to off-Earth commerce assures that ethics are not perceived as foreign in nature, potentially restrictive, or threatening to commercial development. Companies adopting a code of ethics and industry standards may find less resistance to their space development plans, not only in the United States (US), but also from non-spacefaring nations. Less resistance helps companies commit more resources to implement business plans rather than address political or regulatory issues.

According to the International Federation of Accountants, there are three types of corporate codes addressing business practices. The first type is the code of ethics. This perspective is a "statement of the values and principles that define the purpose of an organization."[3] The second type is a code of practice that guides decision-making, and the third type, a code of conduct, prescribes certain behavior. In this chapter, the focus is on the first type, the code of ethics.

Corporations usually create a hybrid of the three types of codes referenced above. A code of ethics, for example, can be constructed as suggested guidelines similar to what may constitute a code of practice. Alternatively, the code may be designed to be extremely forceful, leaving all company employees with a mandate for adhering to strict behavior rules. Depending on how and why the code is designed, the code of ethics may become a vehicle "for reconstituting the power of community ethics and

morality as corporate power, and then deploying it to influence the patterns of thought and action of a corporation's constituents."[4] It is important to remember that a code of ethics is a tool of management created for putting forward ethical, social, and community morality, along with certain policies deemed necessary by the company. A well-designed corporate code of ethics, especially one that is applicable to a new industry or business venture such as space commerce, can help to meet unusual and important aspects of an evolving business environment.

It is important to understand that ethics is about choice. Without the freedom to choose, it is not ethics but law.[5] Most ethical codes are voluntary statements detailing how organizations will conduct business and how associated individuals will behave in their performance of business activities. A code of ethics describes in detail the ethical values to which business will adhere. Ethical behavior requires that individuals involved in a business articulate their ethical values. Creating and accepting a code of ethics helps a company and its employees to determine their ethical values and to codify them within a set of established principles forming the guidelines for their business behavior.

ETHICS FOR OFF-EARTH COMMERCE

Off-Earth economic development will undergo significant changes as Earth-based commerce spreads. As this new era of off-Earth commerce begins, business executives and advocates will decide on what to use as the model of choice for this development. Essentially, there are three models for off-Earth development and settlement: the American frontier model, the imperialistic model, and a twenty-first century model for commercial space development.

The first model is based upon the manner in which America settled its frontier. This model would include the "boomtown or bust" mentality resulting in a sometimes lawless and violent settlement. The second choice is to model off-Earth development after the imperialistic powers of previous centuries wherein wealth was created by using colonies, war, sweat shops, and political control. Imperialism eventually produced riots, unions to protect the work force, and laws to bring order and decency to the growing business communities.

The third model calls for an entirely new twenty-first century vision drawing upon the successes and failures of the past. This new model could be a useful in developing off-Earth resources in a manner reflective of the tremendous advancements evident in today's society. A code of ethics supports the development and implementation of a twenty-first century model

for commercial space development and avoids the costly consequences that burdened businesses as a result of the thoughtless actions in both the American frontier and the imperialistic models.

Unethical Business Practices

An example illustrating an unethical terrestrial business practice gives cause for concern in expanding off-Earth commerce and can serve as an example of what not to do. This particular example involves the tobacco industry that targeted youths in its marketing efforts, covered-up the harmful nature of its product, and formulated its product to make it addictive as possible. These practices have hurt the profitability of the tobacco industry, as it has paid billions of dollars in penalties and fines resulting from private party and government litigation. There seems to be no end in sight for costly legal claims against this industry and individual tobacco companies demonstrating the true costs of pursuing unethical policies in search of quick profits.

Placing profits ahead of customer safety is yet another instance of a lack of ethical leadership in business. This has been demonstrated all too well by the Firestone and Ford organizations and the tragedies associated with their products. Their actions also cost both of these companies money and customer goodwill.

In addition, Health Maintenance Organizations (HMOs) that place profits ahead of the health-care needs of members illustrate unethical planning. This practice has resulted not only in extensive litigation costs for HMOs, but restrictive legislation on both the federal and state level, which is sure to become more restrictive as HMOs continue their typical approach to business. Both the litigation and legislation is certainly raising the operating costs of HMOs. While HMOs pass the increased costs on to their policy holders through rate increase and benefit reductions, it is likely that their overall profitability will be reduced from what it would have been had they been ethical in their approach to business from the beginning. In addition, if HMOs had adopted ethical business practices early on, they would not be encountering the stiff legislative opposition and backlash to their industry that is now common place.

It is fitting to question unethical business practices and make a clear delineation between the inappropriate conduct of business and the type of corporate leadership desired for future off-Earth commerce. As pioneers, there is an implied responsibility for building an ethical foundation for the future citizens of space. Thus, the pioneers should demand the highest

standards possible for future space development. The standards they establish will certainly influence future business leaders, allowing them to see the limitations of unethical thinking, which has the potential to hurt both people and adversely affect company profits. When operating within the parameters of a code of ethics, businesses can demand more of themselves and publicly commit to advancing ethical business practices throughout all aspects of their conduct.

Ethical Challenges

Lunar economic development is significantly closer to reality than that on Mars. Given this fact, two areas in critical need of an ethical approach to future off-Earth commercial development concern the lunar surface and the benefit-sharing of lunar resources. Millions of people are familiar with the NASA pictures of the footprints left by the astronauts in the Sea of Tranquility on the Moon. NASA's caption under the photo reads, "Footprints left by the astronauts in the Sea of Tranquility are more permanent than most solid structures on Earth. Barring a chance meteorite impact, these impressions in the lunar soil will probably last millions of years."[6] In considering lunar economic development, some areas on the surface of the Moon may undergo change that could be permanent. To many critics, this is unacceptable. Furthermore, when lunar-development advocates mention setting aside portions of the Moon for public parks or protected areas, opponents are quick to point out the fact that their activities will forever damage the virgin surface of the Moon. While some critics are focused on lunar development issues, others are focused on making sure that all nations and people have access to lunar resources, a concept that is strengthened by the Moon Agreement.

The Moon Agreement addresses the highly controversial concept of benefit-sharing for lunar resources. Only a handful of nations have accepted the Moon Agreement due to its controversial nature. Both the US and Russia rejected it. Still, the Moon Agreement remains enforceable among those that approved it. The ramifications of the Moon Agreement, with its "commons" terminology and its requirement for benefit-sharing among all nations, strike at the very heart of all off-Earth commerce. A code of ethics, accepted and implemented by off-Earth development companies, would help diffuse the fears and concerns surrounding these issues, and facilitate careful and well-planned off-Earth development.

A Space Law Conference, held in Singapore in 2001, has provided a realistic indication of the magnitude of the future that awaits those seeking to commercially develop the Moon and other off-Earth resources. In opening

remarks the Singapore Attorney General stated, "All nations have a common stake in the resources found within the province of space. However, only a small number are in a position to exploit them. Outer space, like the high seas and the continent of Antarctica, is a common heritage of mankind."[7] Consequently, because of this attitude among many countries, especially developing ones, costly legal challenges to lunar and other off-Earth development projects may be on the horizon as the development of space resources gradually evolves.

Ethics and Benefit-Sharing Issues

Benefit-sharing is a pertinent issue between the developed and developing worlds. There are predictions that developing countries would seek legal compensation from developed countries because of the contribution of the latter to global warming and climatic change. While global warming is not usually associated with off-Earth development, this trend remains noteworthy. If off-Earth commerce is to proceed unfettered by governmental barriers, such as regulatory requirements and direct legal challenges, then the actions undertaken by the commercial space industry to minimize the risk of benefit-sharing is important. Ignoring this issue as well as the larger issue of ethics will likely build future barriers enhancing risk and reducing any potential return on investment.

A successful terrestrial business model is worth examining regarding the concept of benefit-sharing. This model is based upon the oil and gas exploration industry. For any oil company drilling for oil or gas on US federal lease land or lands owned by Native Americans, there exists a pre-determined royalty payment program. The royalty rate is usually fixed at 12.5%. If oil or gas is discovered and can be economically produced, the land owner, in this case the federal government or a particular American Indian tribe, receives its royalty payment off the top of the cash flow stream. The oil company computes the economic cost of the royalty payment into the economics of the transaction; if the drilling deal could not sustain the royalty burden, the venture does not happen. Moreover, the oil company is not involved in the politics and policies concerning how the money is spent or distributed. It simply pays the royalty fee as directed by the lease terms. The federal government and the American Indian tribe decide how the money is to be used through their own procedures of discourse and policy planning.

Should benefit-sharing ever become an obstacle to space commerce, commercial space companies may want to consider establishing a form of royalty payment system similar to what is common in the oil and gas industry.

A royalty rate could be agreed upon by the different parties and the cost of the royalty burden to the venture would be part of the company's economic assessment for the project. An entity, perhaps the United Nations (UN) or one of its functional agencies, would be designated or established to receive the royalty payments. The only responsibility facing the commercial space company would be to make the royalty payments to the designated recipient per the terms of an agreement. As a result of this approach, the commercial space company would be free to focus all of its energies on appropriate business planning, policy making, and management issues. Again, ethics are a key if companies want to reduce the potential political risks of space commercial development.

Off-Earth Settlement and Property Rights

Another problematic aspect emerges from within the space commercial community itself. Characterizing off-Earth settlements as "boomtowns" or "colonies" only encourages discomfort among those already concerned about space development. If off-Earth boomtowns or colonies are developed based on the American frontier or imperialistic models discussed earlier, opposition would be expected, giving rise to protective legislation from governments and the UN.

Space commerce proponents commonly believe that because a venture has private financing, or a company manages to land on a planetary body, the business has an automatic right to all resources it finds. Since private property rights are fundamental to a capitalistic economic system, it is natural to assume that they must be equally fundamental to the development of an off-Earth capitalistic economy. Also, the issue of property rights exacerbates the existing problems with developing countries because they have no means of competing for the rights. In order for space to be economically developed and for individuals to make the necessary investments, property rights must be available to those engaged in the off-Earth businesses and companies. Therefore, it becomes important to apply ethical standards to the creation and the implementation of space property rights.

DEVELOPING A CODE OF ETHICS

A code of ethics for conducting off-Earth commerce can enable organizations seeking to conduct business in this arena to minimize the risks associated with the problems described earlier. It allows for businesses and

companies to recognize the challenges facing commercial development and encourages the participants to devote a high level of thought and analysis to ethical issues. A properly constructed and positive oriented code of ethics secures the commitment of employees and management alike, and establishes a standard for adhering to corporate responsibility. Recalling the unethical business examples cited earlier, most of the companies mentioned had codes of ethics in place. Simply having a code is insufficient. Company leadership, management levels, and employees must share in the commitment to pursue ethical business operations.

The rational thinking about space business and ethics was born from an initial concern for the type of management and leadership businesses would likely take with them into the off-Earth industrial arena. Given that off-Earth settlements and other new business ventures are nearing reality, it is the time to ensure that the best of business practices and ethics became a political priority.

At the end of the twentieth century and in the early part of the twenty-first century, the worst examples of a lack of human concern often proved to be the most successful, the most publicized, the most rewarded, and the most modeled. Companies such as Firestone and Ford, as mentioned earlier in this paper, are examples of this worst case model. Pacific Gas & Electric (PG&E) also qualifies as a worst case example given their refusal to honor disability claims to more than two hundred workers when the company in charge of paying these claims on behalf of PG&E, Pacific Service Employees Association, filed for bankruptcy.[8] During the same time, PG&E won approval from its bankruptcy judge to pay over $17 million in bonuses to executives and key employees.[9] Other examples of corporate irresponsibility, resulting from a company's need to focus on maximizing short-term profits, stock prices, and planning include Global Crossing, Arthur Anderson, Enron, and WorldCom

As these and other companies place all their attention on enhancing the company bottom line, ethical concerns and responsible behavior are likely to be pushed to the back of a long list of priorities. Consequently, it has become increasingly evident that establishing ethical standards for a newly developing commercial space industry is of great import, especially if the significance of building the foundation for future space explorers and settlers is to be thoughtfully considered.

As economic space development ensues, it is important to maintain an awareness of the potential problems resulting from business planning without ethical considerations. A code of ethics addresses these issues by ensuring that only those people offering the highest quality in business management and leadership will participate in building the foundation for the new space

economy. With human nature's best qualities and characteristics represented in the management of the new space businesses, there is a greater likelihood of proper care in sustainable commercialization. This is clearly illustrated by *The Turning Point: Science, Society, and the Rising Culture,* which states that: "We live today in a globally interconnected world, in which biological, psychological, social, and environmental phenomena are all interdependent."[10] As society moves toward an expanded off-Earth economy, the greater the awareness about the interdependence and interconnectivity of the world, the greater the success there will be in commercial space development.

Listed below are some of the major benefits and issues regarding a code of ethics for commercial space development.

> A code of ethics facilitates off-Earth commerce. Ethically focused space business ventures reduce the risk of government interference and popular opposition to this new business development.
>
> Citizen support for developing off-Earth commerce is important. Such support will be more forthcoming with public awareness that this industry consistently adheres to ethical standards.
>
> All commercial off-Earth development will be more carefully considered, planned, and implemented due to committed attention by businesses to ethics.
>
> Businesses will have a wider selection of competent potential employees. Currently, prospective employees inquire into the type of work offered, how the company will use its products and services, the goals and purposes of the business, and how the company plans to evolve successfully. A code of ethics will encourage potential space employees to also inquire into policies instituted to "push the ethical envelope." Candidates will also be encouraged to express their own principles during employment interviews to ensure compatibility with those established by the organization. A business that has adopted a code of ethics can attract higher-level candidates who are genuinely concerned about the ethics incorporated in their work.
>
> Developing an off-Earth economy carries with it responsibilities as a foundation is set for the space explorers and eventual settlers that follow. By publicly subscribing to a voluntary code of ethics, everyone within the company declares their awareness and

> responsibility for ethical space development. The code of ethics is a pledge made by each person to consistently strive to achieve the highest ethical standards in their daily decisions and actions. The incorporation of a code of ethics is a dramatic business-enhancing strategy holding vast potential for success.
>
> With an appropriate code of ethics in place, employees have a higher-level purpose to guide them in their work, bringing greater significance to their jobs. A subsequent increase in professional accountability will follow.
>
> Businesses, which accept and work with a code of ethics, will internally and externally demonstrate quality industry leadership and greater organizational accountability. Company leadership and management committed to adhering to a code of ethics helps to ensure a high level of compliance in responsible corporate behavior.
>
> Businesses, which consistently follow ethical guidelines, will bring the development of an advanced off-Earth economy to fruition.
>
> Safe and thoughtful development of off-Earth resources will benefit the billions of people that live on Earth in a variety of ways. In addition, we will be able to become better "ethical" environmental stewards for Earth.
>
> Acceptance of an appropriate code of ethics will enable space companies to operate from a perspective that is more inclusive and balanced than simply the short-term focus on the "bottom line" and return on investments.

Developing a code of ethics can be an important asset for the commercial space industry as well as for individual companies. A code of ethics has the potential to empower businessmen and woman by calling upon them to carefully consider sensitive issues without dictating how these issues are politically processed. There is an implied assumption within a code of ethics that creative, competent, and committed people will find solutions to difficult problems. As ethics are an inherent part of the political discourse, the company's employees and management become engaged in the political

and policy process. By becoming part of this process, people from the business world with valuable insights, information, ideas, and leadership abilities join forces with public policy-makers. Together, they can facilitate the development of not only a code of ethics, but also public policies that contribute to the expansion of space commerce.

CONCLUSIONS

Adopting a code of ethics for commercial off-Earth development makes practical sense from several important perspectives. First, through assuring people and governments that commercial space development will be pursued in a thoughtful, careful, and ethical manner, potential barriers to space commerce can be minimized or eliminated. Second, adopting an ethical approach to conducting business off-Earth is simply the right, intelligent, and safest action we can take. By both adopting and implementing the principles in a code of ethics, responsible corporate behavior is more likely to result, and this strikes well for the long-term success of the commercial space industry. Furthermore, it is important that the space industry develop its own ethical guidelines for space commercialization. The alternative is risking the imposition of less than favorable guidelines on the industry that will restrict economic development in space. Ethics is inextricably linked to the issues of risk and return on investment so important to commercial development.

Ray Bradbury, a noted science-fiction author, was one of several speakers at the Space Frontier Foundation conference in 1999. This Foundation represents the "Business in Space" advocacy coalition that views the government and governmental policies as constraints on the commercial development of space. Bradbury received a question as to why there is a need for a code of ethics, which suggested that developing space resources and forming settlements on the Moon or elsewhere in space was premature due to the violence, war, and other problems on Earth still requiring resolution. In response to this question, Bradbury offered the following response: "Go into space. Go to the Moon, Alfa Centauri, and Mars. It may not be nice because humans are not nice. But we will also take with us Shakespeare, Emily Dickinson and others. And it will be fine for the human race."[11] As the commercial space industry and space businesses begin operating within a framework of ethics, we will be able to claim the assurance espoused by Bradbury that it will be fine and ethical for the human race.

13
SPACE BUSINESS

Stephen B. Johnson*

INTRODUCTION

Space projects, although dominated by the government for most of their history, have always involved private corporations and academia. While government organizations have generally determined the goals of, and distributed funding for various projects, other organizations outside of the government performed much of the implementation work. For some projects, such as the Surveyor spacecraft in the 1960s, the United States (US) government, through NASA, distributed funds to an academic institution, the Jet Propulsion Laboratory (JPL) of the California Institute of Technology (Caltech). JPL distributed and managed the funds contracted to the Hughes Aircraft Corporation, which built the vehicle. Finally, JPL operated the mission for NASA. The connections between government, academia, and corporations are complex and an inherent part of how space activities are implemented.

In 1997, for the first time, private investment in space projects and operations exceeded that of governments. Because of the government's initial dominance of the sector, private industry has had to work with various government organizations to achieve its goals. Government agencies have often seen private activities as a distraction from their main goals such as the exploration of space, publicly funded applications like weather prediction and Earth observations, and military applications. Private organizations have frequently had to fight for their rights against entrenched government agencies.

At the beginning of space exploration, government policy defined the existence, goals, and means to create space vehicles and operations. As private interests grew, the government eventually responded by creating new institutions and regulations that defined limited government roles such as licensing, regulation, liability, promotion, and access to facilities. To do business in space means doing business with the government, either as a contractor, regulator, or through the many government facilities and institutions involved in space.

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SPACE INDUSTRY BEGINNINGS

The basis for the US government's control of rocketry and missile development was the "negotiated contract." This idea initially emerged prior to World War II with the government's role in acquiring aircraft with the fixed price contract. The government would determine the goals for the aircraft, such as speed, altitude, and payload-carrying ability, and would allocate a fixed amount of money to contract to industry for an aircraft design. If a company spent more than this amount, they had to pay the overrun. The delivered design became government property. Military procurement officers then used the design as the basis for a second fixed price contract for production of a certain number of aircraft. Again, if the contractor overran the cost of producing these aircraft to the government's design, the contractor paid. Under this system, the contractor shouldered all of the risks, and not surprisingly, most lost money due to the significant uncertainties of research and development (R&D) of these complicated devices. Corporations stayed afloat by manufacturing obsolete designs and selling these to foreign countries, and in the late 1920s, by massive influx of funds from private investors to purchase aircraft company stock. With the depression that followed in the 1930s, stock sales disappeared, leaving only exports as a means to stay afloat. This procurement approach left much to be desired, but despite the strenuous protests of the aircraft industry, Congress refused to ease this punishing regime.[1]

Sensing an overseas threat in 1940 after the Nazi conquest of France, Congress passed emergency legislation that allowed the US Army and Navy to use negotiated contracts, cost-plus-fixed-fee contracts, and advance payments, albeit contractor profits were limited. With industry unwilling to expand plant capacity for the war with their own funds for fear of being stuck with facilities with no utility after the war, new congressional laws made possible the huge aircraft industry expansion of World War II. The unanswered question was whether these public laws would continue after the war.[2]

Fortunately for the military, the Procurement Act of 1947 extended the military's wartime authority and tools into peacetime, including the formerly controversial negotiated contract mechanism. The importance of this Act should not be underestimated, for it perpetuated government use of cost-plus contracts. This had important ramifications. To reduce government risk, cost-plus contracts required maintenance of a government bureaucracy sufficient to monitor contractors. Cost-plus contracts also turned attention away from cost concerns to technical issues, which led to higher costs, but also to a faster pace of technical innovation that occasionally led to radical

new technologies. These technologies frequently led to the creation of major enterprises in both public and private sectors.[3]

From July 1940 on, the government's ability to issue lucrative, flexible contracts to academia and industry would be its primary tool to build the military industrial complex. For industry and academia, these contracts, if consistent with their skills and goals, were tempting targets of opportunity. However, the government's goals and contracting policies defined the framework of space business. For the first several decades of space activities, this was by far the dominant type of space business.

Rocketry Development

Rocketry in the US began with Robert Goddard's privately funded effort to create a liquid fueled rocket, which was successfully launched in 1926. In 1930, at the urging of famed aviation pioneer Charles Lindbergh, Goddard received funding from aviation philanthropist Daniel Guggenheim. With this support, Goddard set himself up near Roswell, New Mexico, where for the next decade an increasingly sophisticated series of rockets were developed. The small circle of rocket enthusiasts in the US knew of Goddard's work, but his obsessive secrecy limited Goddard's influence. For example, a Caltech graduate student, Frank Malina, visited Goddard in New Mexico in 1936, but learned little. Malina returned to Caltech empty handed but determined to pursue rocketry.[4]

Malina's efforts paid off, technically and financially. In 1938, Henry H. "Hap" Arnold became the commander of the Army Air Corps. A strong supporter of R&D, and familiar with aeronautical research at Caltech, Arnold persuaded the National Academy of Sciences (NAS) to support Malina's group. After the changes in procurement law in 1940, the Air Corps began to support Malina's rocket project directly. Under the guidance of America's leading aerodynamicist, Theodore von Kármán, the Air Corps wanted Caltech to produce a rocket for Jet-Assisted Take-off (JATO). The first successful test took place in 1941.[5]

Successful testing led to a further funding by the Air Corps for fiscal year 1942. Further technical breakthroughs encouraged von Kármán to look into manufacturing of the new JATO rockets. With existing companies full with war orders, and JATO business yet uncertain, nobody was interested. Von Kármán, Malina, and others created a small company in 1942 called Aerojet. The intended customer, the Army Air Forces (successor to the Air Corps) did not order any JATOs, but in 1943 the Navy ordered large numbers. Aerojet grew rapidly to accommodate them, becoming one of a small number

of rocket and rocket engine manufacturers. Aerojet's success led to its purchase by General Tire and Rubber before the war's end, becoming Aerojet General Corporation.[6]

When the Army Air Forces began to hear rumors of a Nazi rocket (soon to debut as the V-2), the Army Ordnance rocket branch approached Caltech to develop a guided missile. Caltech agreed and established JPL in 1944 to accomplish this task. JPL soon became a permanent operation funded by Army Ordnance, and JPL engineers began development of a series of missiles, starting with Private, the sounding rocket WAC Corporal, and a full-scale ballistic missile known as Corporal.

After the war's end, Army Ordinance continued to fund JPL on a wartime basis. Solid propellant research continued, but most of JPL's efforts focused on the liquid-fueled Corporal. The decision to focus on liquids convinced one of JPL's solid propellant experts, H. L. Thackwell, Jr., to leave JPL for the Thiokol Corporation in 1950, where continued research led to much larger solid propellant rockets based on the "star" configuration. JPL itself would return to solids a few years later with the Sergeant missile, also developed for the Army.[7]

In 1949, after the Soviets' first atomic bomb test, the Army directed JPL to turn Corporal into an operational missile. To produce the missile, at JPL's recommendation Army Ordnance selected Firestone Tire and Rubber Company of Los Angeles. The ground guidance system contract went to Gilfillan Brothers, a Los Angeles electronics firm. Local presence in Los Angeles was an important consideration for JPL, and for Corporal, the three organizations essentially acted as three separate prime contractors for the Army. For JPL's Sergeant missile of the late 1950s, Army Ordnance contracted with Sperry Gyroscope Company to manufacture the missile, and with JPL for technical direction.[8]

JPL significantly influenced the solid rocket propellant industry in the US. Aerojet continued to experiment with solid propellants. The Thiokol Chemical Corporation noticed in 1945 that JPL was purchasing significant quantities of one of its polymers. Curious about the purchases, they discovered that JPL was using it to develop a new solid propellant, and they began experimenting with propellants themselves. In October 1947, the Department of Defense (DOD) included Thiokol in its efforts to develop rockets. By 1950, Thiokol was working with General Electric's Hermes missile, creating the largest solid propellant rocket of that time, and by the mid-1950s was the propulsion subcontractor to Lockheed's X-17 project. Lockheed itself became a major solid propellant contractor with the 1960-61 purchase of Grand Central Rocket Company of Redlands, California. Grand Central was founded in 1952 by Charles Bartley, one of JPL's primary solid propellant experts.[9]

Separately from the JPL tradition, two young engineers from the Massachusetts Institute of Technology (MIT) founded the Atlantic Research Corporation in 1949 to develop solid rocket propellants. This company made a major breakthrough in propellant performance in the early 1950s, verified by separate tests run by Aerojet. Hercules Powder Company, founded in 1912 as an offshoot of DuPont, manufactured explosives and developed propellants for short-range rockets in World War II. In 1945 it took over the management of the government's Allegany Ballistics Laboratory, from which perspective the company was involved with government testing and development of solid propellants.[10]

A final company, United Technologies Corporation (UTC), came late into the solid propellant business. Initially called United Research, UTC became involved with solid propellants at the behest of its first President, retired Air Force General Donald Putt, who had been a student of von Kármán before World War II, and a major force in Air Force R&D circles after the war. Putt hired engineers from JPL, Thiokol, and Atlantic Research for the new business, and quickly gained entry with a large segmented booster for the Titan III launcher in 1962.[11]

World War II also led to opportunities for rocketry on the East Coast. In the 1930s, enthusiasts of the American Rocket Society were performing rocket experiments. One of its members, James Wyld, had developed an ingenious small rocket engine by 1938, and in 1941 returned to it after a hiatus. Fellow Society member Lawrence Lovell showed the little engine to the military in the Washington area, gaining interest from the Navy's Bureau of Aeronautics. Lovell and Wyld, with a few others, quickly established Reaction Motors Corporation to fulfill the Navy's desires for jet assisted take-off. Reaction Motors developed more powerful engines during the war, employing 35 personnel by its end. Immediately after the war, the Army Air Forces contracted with the company for an engine to power its X-1 plane designed to break the sound barrier. Purchased by financier Laurence Rockefeller in 1947, Reaction Motors developed the rocket engine for the X-15, and in 1958 merged with Thiokol Chemical Corporation.[12]

The Navy's interest in JATO engines during World War II funded the growth of Reaction Motors and Aerojet, and also drew Goddard into JATO work during the war years. After the war, the Navy's interest, like that of the Army, turned to air breathing engines and ballistic missiles. The Bureau of Aeronautics formed a Committee to Establish the Feasibility of Space Rocketry in late 1945, performing internal and contract studies with JPL and Douglas Aircraft Company.[13] Under the advice of the Applied Physics Laboratory of the Johns Hopkins University, the Bureau of Ordnance funded the development of a mid-range rocket, smaller than the captured German V-

2's the Army was firing at White Sands, but larger than JPL's WAC Corporal. James van Allen, a scientist with the Applied Physics Laboratory, approached Aerojet, which proposed to create the Aerobee, a scaled up WAC Corporal. The Bureau of Ordnance promptly funded Aerojet and Douglas Aircraft Company for the project, and the Aerobee flew in late 1947.[14]

The Navy initiated a third effort to develop a replacement for the V-2 after the last of these were used up. This large rocket the Navy called the Viking, headed by Naval Research Laboratory (NRL) engineer Milton Rosen. Rosen contracted with Reaction Motors for the engines, and issued a $2 million contract to the Glenn L. Martin Company to build ten, and eventually fourteen vehicles, the first of which successfully flew in 1949. The NRL would team with Martin again later in the 1950s on the ill-fated Vanguard rocket.[15]

Army Ordnance funded JPL, and also acquired Wernher von Braun's rocket team from Germany, along with parts for dozens of V-2s. The Army decided to rebuild and launch these captured vehicles in a program known as Project Hermes. To accomplish this, Army Ordnance contracted with General Electric Corporation to construct the vehicles and to design the ground systems and tracking gear. The NRL provided telemetry equipment to experimenters. Experiments placed on the V-2's sometimes became quite sophisticated, as with the solar pointing control system developed by the University of Colorado for solar spectroscopy. When Ball Brothers Company, a fruit jar firm in Muncie, Indiana, decided to expand into high-technology business, they purchased Control Cells, Inc. of Boulder, Colorado in 1956, renaming it the Ball Brothers Research Center. The new center hired several of the University of Colorado engineers, who acquired contracts to develop pointing control systems for rockets and spacecraft. Ball Brothers in the 1960s expanded to build scientific spacecraft for NASA.[16]

With the acceleration of missile development in 1950 after the Soviet atomic bomb test, Army Ordnance moved von Braun's team to Huntsville, Alabama, renaming it the Army Ballistic Missile Agency (ABMA). As he had done in Germany, von Braun continued to use a concept whereby most development work was controlled and directed inside the government. However, as he found in Germany, the mundane task of manufacturing missiles was best contracted to industry so as to keep the interesting work of R&D in-house. Von Braun's team found that the mainstream aircraft companies were not interested, since they believed that the Army's program would not survive over the long-term against competition from the Air Force. They instead contracted with auto manufacturer Chrysler for production of the Redstone and Jupiter missiles.[17]

Von Braun's influence also reached US corporations through their analysis of the V-2 design. One important example was William Bollay, who

trained under von Kármán at Caltech, and then during the war went to work for the Navy under Robert Truax, who funded both Goddard and Reaction Motors. After the war, Bollay went to work for North American Aviation, which was searching for new kinds of business to compensate for post-war layoffs. Rocketry seemed promising, and Bollay got his hands on V-2 blueprints to copy, and ultimately to improve its engine. Bollay converted one of North American's old buildings into the Aerophysics Laboratory, and in 1947 the company invested in a new rocket testing facility northwest of Los Angeles. With a contract from the Air Force to build the Navaho missile, Bollay built a powerful rocket engine whose derivatives would keep the new Rocketdyne Division of North American busy for decades. The guidance systems group for Navaho later spun off into the Autonetics Division, which thereafter became one of the world's leaders in inertial navigation systems.[18]

Rocketdyne's debut in space came with the Air Force's first Intercontinental Ballistic Missile (ICBM) program, the Atlas. Atlas derived from a contract from the Army Air Forces to Convair Corporation to study ICBM technology under the program name of MX-774. Convair, a production company combined from Consolidated Aviation and Vultee in 1943, created a small prototype that the company funded out of its own money in the late 1940s as Air Force budget cuts forced cancellation of the project. Air Force money returned in 1951 with a study on an ICBM called Atlas. The year 1953 was an important landmark for Convair because the conglomerate General Dynamics purchased the company, and because successful tests of the hydrogen bomb prompted the Air Force to review the program, anticipating missile development. In the next year, the Air Force decided to accelerate the program "as rapidly as technology would allow."[19]

The acceleration of ICBMs came as a component of the new policies of the Eisenhower Administration, which came into power in 1953. Eisenhower's military policy, known as "New Look," emphasized nuclear weaponry over expensive ground and sea conventional forces. The Air Force became the major beneficiary of new funds, and among the Air Force's new weapons, ICBMs were the most promising due to their projected efficiency in terms of manpower and destructive capability. President Eisenhower made them the military's top priority development program in 1955.[20]

Convair hoped to gain the Atlas prime contract, but in this they would be frustrated. Based on the advice of a committee headed by famed mathematician John von Neumann, the Air Force established a new organization in Inglewood (later El Segundo), California under Brigadier General Bernard Schriever. Agreeing with the scientists, Schriever concluded that Convair did not have the requisite expertise, and instead hired the newly-

formed Ramo-Wooldridge Corporation to aid the Air Force with systems engineering and technical direction of the ICBM program.

Simon Ramo and Dean Wooldridge, the company's founders, hailed from the Hughes Aircraft Corporation, where they had established the largest group of masters and Ph.D. level scientists and engineers in industry outside of American Telephone and Telegraph's (AT&T) Bell Laboratories. With this expertise, Hughes had gained a near monopoly on electronics for high-performance aircraft and missiles. This worried Eisenhower's Secretary of Defense Charles Wilson, formerly the head of General Electric and later General Motors. Wilson privately encouraged Ramo to form a new company to break Hughes' monopoly on electronics. Ramo complied with this request, and the Air Force soon rewarded the move with the contract for technical direction of the ICBM program.[21]

RamoWooldridge's Air Force funding grew rapidly along with the ICBM program, from $25,000 prior to June 1954 to over $10 million from July 1955 to June 1956. Needing cash for new facilities and to take advantage of other contracting opportunities, Ramo and Wooldridge sought and received further funding from Thompson Products, an automotive and aviation component manufacturer that had been a major investor in Ramo-Wooldridge Corporation at its founding in 1953. Over time, Ramo-Wooldridge's voracious appetite for cash led to arrangements that would make Thompson Products the majority owner of the company. The two companies' executives decided to merge their assets, forming Thompson-Ramo-Wooldridge, or TRW, in 1958.[22]

Schriever eventually decided to award Convair of San Diego the contract for the Atlas airframe, while North American's Rocketdyne Division built the propulsion. Guidance first used a radar system built by General Electric and an on-board computer built by Burroughs. Later American Bosch Army built an all-inertial guidance system. Contracts for reentry vehicles went to General Electric, and later to AVCO. Still unsure if the Atlas' advanced technologies would function, Ramo-Wooldridge and Schriever's officers pushed for and received authority to build a two-stage back-up missile called Titan. Approved in January 1955, Titan's airframe contract went to the Martin Company, which was in financial straits in the early 1950s and had essentially given up on aircraft to focus on missiles. Since the Air Force wanted to disperse the missile companies outside of California, Martin agreed to build a new facility southwest of Denver, Colorado. Other major contracts went to Aerojet General for the engines, the radio guidance system to Bell Telephone Laboratories, a guidance computer to Remington Rand UNIVAC, an all-inertial guidance system to AC Spark Plug, and reentry vehicles to AVCO and General Electric.[23]

Schriever's group continued to expand along with its programs and contractors. Needing a way to rapidly test reentry vehicles before Atlas was completed, the Air Force funded Lockheed to build the X-17, a solid-rocket system with an experimental reentry vehicle. Another program, the Thor intermediate range ballistic missile, was a response to the Soviet Union's R-5 missile deployed to threaten Europe. Determined to provide an immediate response to the Soviet threat, the Eisenhower Administration demanded development of a long-range missile. Ramo-Wooldridge engineers quickly defined the system, and the airframe contract went to Douglas Aircraft Company of Santa Monica, California. Rocketdyne again received the engine contract, with AC Spark Plug providing the guidance systems, and General Electric the reentry vehicle.[24]

By 1958, Air Force propulsion expert Colonel Ed Hall found that solid-propellant missiles were now feasible to build, leading to the establishment of the Minuteman ICBM program. Solid propellant missiles would soon sweep the liquid-propellant systems out of the missile fields, since they were safer, more reliable, and able to launch in seconds as opposed to hours. Boeing won the airframe contract, and Thiokol, Aerojet, and Hercules acquired the first, second, and third stage propulsion systems. Guidance systems went to North American's Autonetics Division, and reentry vehicles to General Electric and AVCO.

Table 13.1 highlights the historical evolution of rocketry development. In the end, the liquid-fueled systems, forced out of the missile business by the late 1960s, were converted to become launchers for the new technology of spacecraft.[25]

Table 13.1. Historical Evolution of Rocketry Development.

Rocket	Funding Agency	Designer	Manufacturer	Year
Corporal	Army Ordnance	JPL	Firestone	1945
Aerobee	Navy Bureau of Ordnance	Aerojet Applied Physics Laboratory	Aerojet	1946
Viking	Navy Bureau of Aeronautics	Martin Naval Research Laboratory	Martin	1946
Redstone	Army Ordnance	ABMA	Chrysler	1950
MX-774	Army Air Forces	Convair	Convair	1945
Atlas	Air Force Western Development Division, WDD	Convair R-W	Convair	1950
X-17	Air Force WDD	Lockheed	Lockheed	1954
Titan	Air Force WDD	Martin R-W	Martin	1955
Thor	Air Force WDD	Douglas R-W	Douglas	1956
Jupiter	Army Ordnance	ABMA	Chrysler	1956
Minuteman	Air Force Ballistic Missile Division	Boeing R-W	Boeing	1958
Polaris	Navy Special Projects Office	Lockheed	Lockheed	1956

BUILDING AN AMERICAN SPACE INDUSTRY

The initial American strategy to develop and deploy spacecraft was an outgrowth of another aspect of Eisenhower's New Look policy. Eisenhower, the former commander of Allied Forces in Europe in World War II, was familiar with the problems of military operations. From those experiences, Eisenhower knew that among the most important elements for military success was accurate intelligence of enemy activities. With the Soviet bloc a closed society, and the US military demanding to build expensive new weapons to counter their guesses at what the Soviets might be building, Eisenhower was convinced of the necessity for hard photographic and signals intelligence upon which to base weapons acquisition decisions. The President authorized a few overflights of the Soviet Union, and pushed for the development of new technologies for reconnaissance. A highflying aircraft known as the U-2 was the result, along with a program to develop a military reconnaissance satellite.[26]

The reconnaissance satellite program already had a small basis upon which to grow. In 1946 the Army Air Forces launched a major study in 1946 of the possible uses of spacecraft through Project RAND, a small analysis group within Douglas Aircraft. The Army Air Forces funded this group to perform advanced studies of tactical and strategic operations and future technologies, which required that the group have access to sensitive military plans. With possible charges of conflict of interest in mind, Donald Douglas separated the group from the company so as to avoid compromising Douglas Aircraft's chances for lucrative production contracts. This led to the founding of the non-profit RAND Corporation in 1948, the first modern "think tank." Although the satellite idea did not gain military support at the time, RAND nurtured the idea until Air Force support ensued.[27]

Within the Air Force, and at the highest levels of the Eisenhower Administration, the utility of satellites for reconnaissance became apparent by early 1955. Eisenhower feared a surprise attack by the Soviet Union on the US, and to alleviate this concern, a top-secret study was ordered in 1954. This study recommended an acceleration of ICBM efforts, the development of a reconnaissance satellite, and the establishment of the principle of "freedom of space." With overflights of the Soviet Union illegal but ongoing, Eisenhower knew it was only a matter of time before the Soviets would shoot down an American spy plane. The hope was that overflying the Soviet Union from space would be a different situation, with the principle of flight through space established as similar to freedom of the high seas. The report suggested the possibility of orbiting a scientific spacecraft to establish the principle. In 1955, the National Security Council (NSC) approved this idea as official

government policy, and Eisenhower officially announced the policy of "Open Skies," whereby the United States advocated supervised overflights by the Soviet Union and the United States of each other's national territory. Further, Eisenhower announced that the US would launch a satellite for the International Geophysical Year (IGY) of 1957-58.[28]

To launch a non-threatening satellite in order to establish Open Skies, the Administration asked that the US IGY panel request that the government launch a scientific satellite to support this international scientific effort. The panel complied, and a committee of experts deliberated between Army and Navy proposals for the spacecraft, with the Air Force declining to bid, since it was already busy on the secret reconnaissance satellite. To launch the scientific satellite, the NRL contracted with the Martin Company to build a new rocket based on the earlier Viking built by the NRL-Martin team. The new rocket, called Vanguard, was fated to start its testing after the Soviets launched Sputnik.[29]

In the meantime, the Air Force requested bids for its reconnaissance satellite, called Weapon System WS-117L. Lockheed, already working on the X-17 system, won the contract in 1956. Soon the Eisenhower Administration cancelled the reconnaissance portion of the WS-117L program, and reconstituted it covertly under joint Central Intelligence Agency (CIA)–Air Force management under the name CORONA. For the new film-return system, Itek designed the camera system, and General Electric the reentry system that would bring film back to Earth. After twelve failures, the first successful CORONA flight came in August 1960.[30]

Early warning against Soviet bombers was another critical element to protect the military's ability to strike back against the Soviet Union. Already in the Truman Administration, propelled by the Soviet atomic bomb test of 1949 and the Korean War in 1950, the Air Force began to modernize American air defenses. The core of the new system was to be a digital computer under development at MIT. MIT leaders agreed to help, but only if all of the services cooperated to support the project. With tri-service funding and guidance, MIT created the Lincoln Laboratory, whose first project was the SAGE (Semi-Automatic Ground Environment) with the first real-time computer system.[31]

Once the interesting R&D work was completed, MIT leaders were not interested in continuing to develop and operate SAGE, yet by 1957 it was clear that Lincoln's expertise would be required for years to come. After polling different companies involved with SAGE, which included Bell Laboratories, International Business Machines (IBM), and Burroughs, the Air Force concluded that the best solution was the creation of another non-profit corporation modeled on RAND, but focused on systems engineering and technical direction. The new company, called MITRE, came into being in

1958, and has worked in this capacity for Air Force electronic systems ever since. Lincoln Laboratory refocused its efforts on cutting edge military R&D, particularly communications systems, including communications satellites.[32]

Reconnaissance remained the centerpiece of the Eisenhower Administration's policy, but the hope to keep the space budget under control went out the window when the Soviets launched Sputnik in October 1957. Lyndon B. Johnson launched a Senate investigation that highlighted the Administration's purported incompetence. The public and congressional outcry forced Eisenhower's hand, driving space and missile spending ever higher.[33]

Aircraft industry leaders took the opportunity to criticize the Air Force's relationship with TRW, claiming rightly that the Air Force was creating strong new competition. Their complaints meant little in the mid-1950s as the US struggled to overcome the fictitious "missile gap." TRW had access to government plans and to the technical expertise of the companies that it monitored, and the hardware ban on TRW now evaporated as it acquired contracts to build scientific spacecraft in the rush to place anything into orbit. More congressional investigations followed, and eventually the Air Force had to relent. The Air Force sponsored the creation of The Aerospace Corporation, a non-profit corporation modeled after RAND and MITRE. It became the Air Force's systems engineering and technical direction contractor for Air Force space projects. The creation of The Aerospace Corporation showed that there were limits to the government's contracting authority, as the aircraft industry was ultimately able, through its congressional representatives, to sever the Air Force's relationship with TRW. But as industry leaders had feared, TRW had become a powerful new competitor.[34]

The Eisenhower Administration's primary responses to Sputnik were to reorganize military space efforts and to separate civilian applications from DOD altogether. Reorganization of military space efforts involved two major changes in 1958. The first was a change in authority of the position of the Deputy Secretary of Defense for Research and Engineering (DDR&E) in the Office of the Secretary of Defense in the Defense Reorganization Act of 1958. From this time forward, the DDR&E was responsible for all DOD R&D programs, including their funding. Secondly, the DOD created the Advanced Research Projects Agency (ARPA) to manage all military space programs. ARPA was unable to control the services and in December 1959 was redirected to perform high-risk research for the DOD under the DDR&E. In this new task ARPA would perform admirably, among other things sponsoring the creation of the Internet and artificial intelligence.[35]

Eisenhower's concern to ensure civilian control of the military and to provide a peaceful face of American space activities to distract attention from

space reconnaissance led to the promotion of a civilian space agency. After considering several alternatives, Eisenhower and Congress agreed to base the new civilian agency on the National Advisory Committee for Aeronautics (NACA). NASA came into existence in 1958, with the older NACA facilities as its core, as well as the Vanguard group from NRL and some personnel from the Army Signal Corps. By 1960, NASA also acquired the Army's two major space organizations, ABMA and JPL. NASA also inherited the same procurement regulations as DOD, including the all-important right to use negotiated contracts.[36]

From the standpoint of private business, NASA was a potential new source of government contracts, using essentially the same procurement processes as the DOD. NASA inherited many of its programs from DOD, and hence inherited the same contractors. For new initiatives, such as the Mercury program to place a human in orbit around the Earth, NASA placed bids in the same way as the DOD, although NASA's engineers were often more prone to change their specifications than their DOD counterparts. For Mercury, McDonnell Corporation won the capsule contract, while the ABMA (renamed NASA's Marshall Space Flight Center, MSFC) supplied the Redstone rocket for sub-orbital flights, and the Air Force provided Atlas launchers for the orbital missions. For the boosters, NASA did not contract directly with Chrysler or Convair, but rather with the Army and Air Force, who managed these contracts on NASA's behalf.

Space Projects of the 1960s

To acquire contracts from NASA or DOD, companies targeted specific application areas in which they might have a competitive advantage, or in which their contacts with the customer were close. The latter consideration was particularly important, because winning contracts often meant being able to accurately decipher the customer's intent, as opposed to having superior technical abilities. Furthermore, since each particular contract opportunity meant interactions with a specific small group of individuals in NASA or the DOD, interactions with those specific individuals were critical. The space industry, like the aviation industry before it, was not a mass market. Marketing skills to specific individuals or groups was essential to success.

As an example, when NASA put out bids for the Apollo Command and Service Module in 1962, the Glenn L. Martin Company won the competition based on its overall score. Despite the winning score, NASA Administrator James Webb did not believe in Martin's ability to work with astronauts, because Martin's engineers had not worked with aircraft and test

pilots for over a decade. By contrast, the second highest scoring bid, by North American Aviation, featured its concurrent expertise with NASA's test pilots on the X-15 program. North American's proposal aimed to determine NASA's approach, and then "reflect it right back as faithfully as a mirror." NASA ultimately picked North American over Martin. In another case, the MIT Instrumentation Laboratory won the Apollo guidance computer contract because James Webb personally knew and trusted Charles Stark Draper, MIT's inertial guidance expert.[37]

Acquiring research contracts from NASA's research centers, the three former NACA centers of Langley, Lewis, and Ames, was a tricky business because the competition involved many more organizations. For these centers, as well as for DOD's research organizations, such as the Office of Naval Research or the Air Force's Office of Scientific Research, the competition for funding included not just industry, but also the government's own laboratory personnel, non-profit corporations, such as RAND, MITRE, and ANSER, academic institutions, such as MIT's Lincoln Laboratory, as well as individual faculty members with the requisite expertise. Hundreds of small contracts went out each year from NASA and DOD for studies, small components, instruments, tests, software, consulting, or a variety of other tasks. In these competitions, even more than in the larger contracts, success depended on having a good technical reputation among the small group of government experts controlling the funds. This required active marketing of personal skills at professional or government-funded conferences and symposia, active publication of results, and informal networking among the typically small number of individuals that were experts in a given narrow field.

Since NASA's personnel hailed from government research institutions, one quality many of them shared was a "hands-on" tradition that differed from the DOD's large contracts run by military officers. Virtually all of NASA's early programs featured significant involvement of NASA engineers in design and manufacturing, even when they nominally contracted out for these functions. At MSFC and JPL in particular, contractors often complained that these centers managed contracts by technical takeover. Trusting their own abilities far more than those of their contractors, MSFC and JPL personnel typically designed new missions and vehicles themselves, and then reluctantly handed them to industry only after the interesting development work was completed and the contractor had sufficiently demonstrated their technical competence. Even then, both organizations emphasized "contractor penetration" to ensure contract performance. Throughout the 1960s and beyond, JPL and NASA's Goddard Space Flight Center continued to design and test spacecraft internally. All NASA projects

used NASA personnel to launch and operate the spacecraft, excluding businesses from this function, except for supplying computer system hardware and software to support operations.[38]

One of NASA's main challenges was to move its engineers away from in-house design to more significant use of contractors. With rapidly expanding budgets and programs, but limitations on the number of civil service personnel, NASA simply did not have enough personnel to design all of the vehicles needed for its various programs. In addition, contracting to industry had the important benefit of spreading money around the country, ensuring political support through congressional representatives for those districts. In the manned space program, NASA eventually brought in Air Force veterans to move NASA's managers toward Air Force style contracting. George Mueller from TRW and Air Force Brigadier General Samuel Phillips led these efforts, with Mueller heading the Office of Manned Space Flight from 1963, and Phillips directing the Apollo program from 1964 to 1969. Ultimately, NASA informally used the "10% rule" for contracting. NASA kept 10% of funds in-house to train its own engineers and gain experience, and the remaining 90% went to industry.[39]

In 1960 John F. Kennedy was elected the President of the US, largely on the claim that the Eisenhower Administration had been too passive with regards to missiles and space. The decision in the spring of 1962 to put a man on the Moon ushered in an era of massive growth for NASA, and hence more opportunities for business in piloted spaceflight. This allowed some aircraft companies who had not yet cashed in on the space and missile business to enter the field, such as Grumman, which won a contract for the Apollo Lunar Module. More significant were changes to policies governing DOD, and for the first purely commercial space efforts.

Kennedy selected Ford President Robert McNamara to be the Secretary of Defense in 1961. McNamara shared Kennedy's activism, and planned to bring sound business management principles to the DOD. McNamara immediately instigated a series of studies to investigate various aspects of DOD. One of the study recommendations was to spend more up-front effort to define the costs and schedules of new DOD development programs, a course that fit McNamara's "by the numbers" management style. On the Titan III program to create a heavy-lift booster for the DOD's Dyna-Soar piloted spacecraft, McNamara first implemented the policy, requiring the Air Force and its contractors to spend six to nine months defining the project's objectives, costs, and schedules in a "preliminary design phase." This extra step in the process defined what the DOD dubbed "phased planning," which became the DOD standard by the mid-1960s. NASA adopted the process in 1967.[40] McNamara also implemented the Programming, Planning, and Budgeting System across the DOD to provide

for long-term budget forecasts corresponding to technical and strategic assessments, and to unite the formerly separated budgeting and spending processes. This system remained a DOD standard, enforcing civilian control of the military.

By 1961 the Air Force's Ballistic Missile Division had developed another critical management process: configuration management. Configuration management was a technique to tie engineering changes to cost predictions, and hence to cost control. The idea was straightforward. Once a new system had been designed, that design was "frozen," meaning engineers could no longer arbitrarily change it. This design was the basis for cost and schedule estimates. Any change to this design required approval of a configuration control board, which included the manager responsible for the budget. All changes required estimates of the cost and schedule impact of the technical modifications, allowing the manager to trade off the costs of a change to its benefits. This system quickly spread throughout DOD and NASA, becoming a primary contractor control process. The new system required significant amounts of formal documentation, but it also enhanced the reliability of systems being built. It became a standard process throughout the aerospace industry.[41]

While the government honed its procurement procedures, private industry looked eagerly at one promising opportunity to make a profit in space- satellite telecommunications. In this field, AT&T had a strong interest. AT&T, whose budget was larger than that of NASA, operated a near-monopoly on telephone services throughout the US, with connections to and branches in many other countries. Excluded from the radio business in the 1920s, AT&T saw space as an opportunity to expand into wireless communications and the new field of satellite communications, which promised to significantly lower the cost of providing overseas telephone services, which were then handled by undersea cables. By the late 1950s, AT&T was investigating two satellite designs for the purpose. The first, a passive communications satellite named Echo, was a very large spherical balloon with a metallic exterior off which to bounce radio signals. This project, begun prior to the formation of NASA, was a NACA and then NASA funded project, including AT&T and JPL for the communication links, and General Mills to build the balloon, which successfully launched in August 1960. The second, more sophisticated satellite was an active system that could receive, amplify, and retransmit signals. AT&T funded this project, known as Telstar, with its own money. However, the company needed a ride into space, and this meant it had to work with NASA, which in 1961 agreed to provide a launcher if reimbursed by AT&T.[42]

Keith Glennan, NASA's first administrator, had cautiously supported AT&T's efforts to develop a private communications satellite system. However, the Kennedy Administration was dead-set against this outcome, and made it clear to NASA's leaders that AT&T was not to win the race for satellite telecommunications. In addition, many of NASA's leaders wanted their organization to control new developments in space, even if industry was willing to foot the bill. Hughes Aircraft, General Electric, Radio Corporation of American (RCA), and Lockheed expressed interest in satellite communications. Whereas AT&T could raise venture capital and fund private systems internally, the other companies required government assistance. The question facing NASA was how to fulfill its own charter to lead civilian space efforts, given that a decision to fund or not to fund private industry would favor one or other of these corporations. NASA and DOD, with the strong direction of the Kennedy Administration, decided to fund early system development to ensure that AT&T in particular would not control satellite communications by default. By 1961, four active satellite programs were underway: AT&T's Telstar, NASA's Relay contract to RCA and Syncom contract to Hughes, and the DOD's contract to General Electric for Advent.[43]

In 1962, Congress introduced three bills for satellite telecommunications. One called for private ownership and development, another for government development and control, and the third, ultimately approved, was a compromise between the two. President Kennedy signed the Communications Satellite Act in August 1962, which called for the government to create a private corporation, known as the Communications Satellite Corporation (Comsat), to operate the new satellite system, and to negotiate on behalf of the US with other countries, since overseas communications obviously required their active involvement. The government allowed communications carriers to purchase half of its stock, although the government limited AT&T to purchase only 29% of Comsat stock. Private investors purchased the remainder. In 1964, Comsat became the manager of the new international system under the International Telecommunications Satellite Organization (Intelsat). Comsat eventually selected Hughes' geosynchronous orbiting satellites for its experimental test, and for its initial constellation of four satellites supported by a contract from NASA. TRW won a contract in December 1965 for an advanced system of six spacecraft. In the meantime, DOD decided that it could not use a system that had foreign participation, and it opted for its own system, contracted to Philco and first launched in 1966.[44]

The US government profoundly influenced the satellite communications market. First, it explicitly prevented AT&T from establishing a new monopoly in space telecommunications. Second, through NASA and the DOD, it funded a host of competitors that would collectively

dominate communications satellite manufacturing through the next several decades: Hughes, RCA, Philco (later Ford), TRW, and General Electric. Third, it created a new government-sanctioned corporation, Comsat, to control its interests in the new industry. Finally, the government regulated the control of the frequency spectrum through the Federal Communications Commission (FCC) and with the International Telecommunications Union (ITU). Through all of these mechanisms, and industry's own funding and efforts, the US would dominate the profitable industry for decades.

Through the middle of the 1960s, rapid growth characterized the new space industry in terms of investments, organizations involved, and in types of applications. NASA's spacecraft included the massive manned space projects, planetary probes, orbiting observatories and science-craft, and applications satellites for communications and weather. The military had its own satellite programs, some of which overlapped those of NASA, such as for weather and communications. Other military applications differed significantly from the civilian programs, such as initial experiments in space navigation through the Transit satellite, tracking of space objects through the Spacetrack and SPASUR systems operated from Cheyenne Mountain in Colorado Springs, optical and electronic intelligence gathering systems, and early warning systems to detect missile launches and nuclear explosions. The new missions required new launchers, such as NASA Langley's Scout built by Ling-Temco-Vought (LTV), the Lewis Research Center's Centaur upper stage built by General Dynamics' Convair Division, and MSFC's massive Saturn launcher built by Boeing, Douglas, and North American.

Success brought its own problems. Several important mergers occurred in the late 1960s, all motivated by concerns to maintain success in the face of current growth and prospective declines in the aerospace industry. Douglas Aircraft had won a number of commercial and military aircraft contracts that put it in the position of being unable to fulfill orders due to difficulties in recruiting and training workers and a lack of capital to expand its facilities. Several companies tried to purchase the company, but McDonnell Corporation eventually succeeded in 1967. McDonnell was much smaller, but had an excellent reputation with the government with its F-4 Phantom aircraft, and its successful work on Mercury and Gemini. The new company, McDonnell-Douglas, continued as a powerful presence both in aviation and space, with Douglas' expertise in launchers with the Thor-Delta rockets, and McDonnell's experience with manned spacecraft.[45]

Two other companies, Martin, and North American, were worried about the prospects of decline, and sought alliances. Martin decided to merge with American Marietta Corporation, a company focused on construction materials and aggregates, becoming Martin Marietta in 1961. The Rockwell

Standard Corporation, which concentrated on automotive parts and machinery, merged with North American, becoming North American Rockwell. Both of these mergers were typical of the 1960s, when diversification was a prominent corporate trend. As it turns out, diversification was a wise move for both companies, as an aerospace downturn was indeed on the horizon.[46]

Table 13.2 lists the major space projects, discussed in this section, which underlined the development of the space industry in the 1960s. In all of these efforts, government and industry teams grew at a tremendous pace, and interacted in complex ways that had been established with the contractual business practices (the "negotiated contract") of the late 1950s.

Table 13.2. Major Space Projects of the 1960s.

Project Name	Manager	Contractor
CORONA	NRO	Lockheed
Mercury Capsule	NASA	McDonnell
Dyna-Soar	USAF	Boeing
Gemini Capsule	NASA	McDonnell
Saturn IB; Saturn IC; Saturn S-II; Saturn S-IV	NASA	Chrysler; Boeing; North American; Douglas
Apollo Command and Service Module	NASA	North American
Apollo Lunar Excursion Module	NASA	Grumman
Surveyor	JPL	Hughes
Mariner	JPL	JPL
Manned Orbiting Laboratory	USAF	McDonnell
Defense Support Program	USAF	TRW
Orbiting Solar Observatory	NASA	Ball
Intelsat II; Intelsat III	Comsat	Hughes; TRW
Lunar Orbiter	NASA	Boeing
Initial Defense Communication Satellite Program	USAF	Philco

SPACE SHUTTLE ERA

With the end of Apollo approaching, détente, the Vietnam War at its height, President Johnson's "Great Society" program underway, and student and racial unrest tearing at America's social fabric, the space build-up ongoing since the 1950s finally slowed, and for NASA and its contractors began a massive decline. With funding shifted to social and environmental

priorities, government space funding slowed, and cost concerns increasingly determined government space endeavors. In the meantime, communications satellites steadily grew in importance, showing long-term economic stability. In 1965, NASA's total appropriations peaked at $5.25 billion dollars (close to $30 billion in 2002 dollars), dropping slowly for the next two years, and precipitously after that. Accounting for inflation, NASA's budget reached its low point in 1975 at about one-third of the 1965 appropriation, and remained roughly at that level until the early 1980s when it slowly began to increase. While the majority of these cuts impacted the manned space program, NASA's space science programs were also affected. Given that the cost of space projects continued to increase, reflecting the increasing complexity of the missions NASA wanted to accomplish, the number of projects dramatically declined. Contractors wanting to remain in the space business had fewer opportunities, and competed vigorously for the few new projects that became available.[47]

Similar trends affected DOD. Although its space funding also shrank, it did not decline as much as NASA's in the early 1970s. Military spacecraft also became more complicated, leading to smaller numbers of spacecraft. In addition, some of DOD's programs required constellations of identical or near-identical spacecraft, making the competition for these blocks of spacecraft very fierce indeed. In the National Reconnaissance Office's (NRO) satellite reconnaissance systems, changes in technology made the film-bucket CORONA obsolete. Instead of the many launches required to maintain a reconnaissance system in space, the NRO's new systems radioed their data back to Earth. Whereas typical CORONA missions lasted a few days or weeks, the new spacecraft remained on-orbit for years.

For launch vehicle contractors, the combined effect was a drastic reduction in numbers of launches from the 1960s to the 1970s, along with an increase in mass of many of the payloads. Douglas Company's Thor-Delta was the biggest loser. New heavy payloads launched instead on Martin Marietta's Titan or General Dynamics' Atlas. Even more disconcerting for launch vehicle contractors were the implications of the new manned spaceflight program, the Space Transportation System (STS), or Space Shuttle.[48]

As the Apollo program's goals came into sight in the late 1960s, NASA executives, particularly manned space leaders such as George Mueller, began to plan for the post-Apollo future. In the short-term, Mueller focused on uses of Apollo hardware, which eventually metamorphosed into Skylab, the first American space station. Launched in May 1973, Skylab was a converted Saturn third stage, for which contracts worth $709 million went to McDonnell Douglas. Martin Marietta won contracts for $321 million to

integrate the payload and experiments. However, beyond Skylab, NASA's plans remained obscure.[49]

The Nixon Administration, led by Vice President Spiro Agnew, asked for NASA to make recommendations for its future plans. These plans, know as the Space Task Group Report, called for a space station, a manned Mars mission, and a space shuttle to make both possible. The recommendations quickly fell to the wayside, and the administration and Congress whittled NASA's grandiose plan down to the Shuttle. Belatedly realizing that cost was the major issue, NASA leaders proposed building a shuttle to dramatically lower the cost of space access. The next two administrations under Ford and Carter would continue to emphasize the necessity of strict economy measures for NASA, and place more emphasis on practical applications such as Earth remote sensing and cheaper space transport, as opposed to space exploration and pure science.[50]

Low cost required frequent flights, which in turn meant that all possible payloads would have to fly on the Shuttle. Since DOD was the largest customer for spacecraft needing rides into space, NASA had to get DOD's agreement. Despite some skepticism, DOD went along with the idea, but only if the Shuttle could handle the DOD's requirements. Two of these significantly modified the Shuttle design. First, the Shuttle would have to be able to lift the DOD's largest spy satellites then under design, the KH-9 "big bird." This entailed an increase in the payload bay size and the Shuttle's lift capacity. Second, the Shuttle would have to have the capability to intercept and capture a spacecraft, and return back to the US in one orbit. This required a much larger cross-range capability, which in turn required larger wings. The overall impact was to create a much larger shuttle with higher performance, significantly reducing its overall economic efficiency. Finally, to meet the objections of the Office of Management and Budget (OMB), the development cost had to be kept as low as possible, which ultimately meant replacing a liquid-fueled fully reusable shuttle with a partially reusable system with strap-on solid rockets. These changes would doom the Shuttle to be a high-performance, difficult to maintain system that would never come close to the high flight rates needed to achieve low cost.

Approved in 1972, NASA subsequently spread contracts around to keep industry appeased. Rockwell received the lion's share of funding, building the orbiter and the main engines. Grumman built its wings, General Dynamics part of the fuselage, McDonnell Douglas the orbital maneuvering system, Martin Marietta the external tanks, Lockheed the thermal protection system, and Thiokol the solid rocket boosters. Once the Shuttle began to fly in 1981, only Rockwell, Thiokol, Lockheed, and Martin would have significant ongoing roles with hardware: Rockwell because it was the integrator of the system, Martin because each flight required a new external

tank, and Rockwell, Lockheed, and Thiokol because the engines, thermal tiles, and boosters had to be refurbished and eventually new ones built.[51]

While the Shuttle remained in development, the primary US launchers, Scout, Delta, Atlas, and Titan, would continue to fly American and foreign payloads into space. However, the Shuttle decision meant that their future was limited. Eventually the Shuttle's flight frequency would rise, its average launch cost would fall, and expendable launch vehicles (ELVs) would become a thing of the past, or so the logic went. It made little sense to upgrade ELV technologies if they were to become obsolete, so neither NASA nor DOD put much money into upgrading them. By the early 1980s, with no more orders forthcoming, all four major vendors, LTV, McDonnell Douglas, General Dynamics, and Martin Marietta, were planning to shut down their ELV manufacturing lines. For the contractors, the principle of the Shuttle was disturbing; the government was removing business from private corporations in order to hand it over to a government monopoly. While the big three contractors had a hand in the Shuttle's design and manufacturing, this was poor compensation for the eventual shutdown of their profitable launcher businesses.[52]

One option to remain in the business was to adapt to the Shuttle's constraints, and to build upper stage rockets necessary to boost payloads from low Earth orbit (LEO), which was as far as the Shuttle could fly, into the orbits needed by various spacecraft. The Air Force agreed to fund a shuttle-compatible upper stage known as the Inertial Upper Stage, contracted to Boeing. McDonnell Douglas developed its own upper stage, known as the Payload Assist Module. General Dynamics successfully lobbied NASA to fund modifications of its Centaur upper stage to make it shuttle-compatible. In addition, a new company, Orbital Sciences Corporation (OSC), formed in 1981 to build a new shuttle-compatible upper stage known as the Transfer Orbit Stage.[53]

Companies adopted a variety of strategies to deal with the new vehicle, and its opportunities and constraints. McDonnell Douglas promoted the idea of manufacturing Pharmaceuticals and chemicals in space, and managed to convince Ortho Pharmaceuticals in 1978 to perform some experiments towards manufacturing an anemia treatment hormone in space. Astrotech Space Operations began in 1980 with the idea of processing experiment payloads that would launch on the Shuttle. By 1985, it was a successful on-going business, with contracts with all of the Shuttle's commercial customers. Believing correctly that NASA's next major project would be a space station, the major aerospace firms remained committed to NASA's programs in hopes of participating in it.[54]

The DOD had agreed in the early 1970s to support the Shuttle, and began to prepare itself for the new era as well. By 1979, with Shuttle operations imminent, the Air Force began a series of organizational changes that separated R&D from space operations, ultimately culminating in the creation of Air Force Space Command in September 1982. New Shuttle support investments included a classified facility at NASA Johnson Space Center, a Shuttle launch facility at Vandenberg Air Force Base in California, and a Consolidated Space Operations Center based in Colorado Springs. Establishment of centralized space operations in Colorado hinged largely upon the US alliance with Canada in North American Aerospace Defense Command (NORAD), as the Canadians were deeply involved with space and ground-based early warning systems with the US armed forces. During the 1970s, the military largely continued and expanded programs already underway or in early research during the 1960s. For example, improvement to military communications satellites and early warning systems continued, as well as a follow-on to Transit called the Global Positioning System (GPS). Procurement reforms tinkered with processes in the 1960s, but did not significantly change them for space systems.[55]

The Navy experimented with shipboard communications satellites in the 1960s and early 1970s, but found themselves in a bind in the early 1970s, as they ran into technical problems on their next-generation system called Fleet Satellite Communications, or FltSatCom. To fill the gap between their early experimental systems and their anticipated new system of the late 1970s, Comsat Corporation proposed to fund and operate a commercial system of three satellites that the Navy could lease. Hughes built the Marisat spacecraft, and Comsat launched them in 1976, where they soon became very popular not only with the US Navy, but also private shipping companies, becoming the de facto standard for maritime use.[56]

During the 1970s, purely private communications satellite programs also began. The Intelsat agreement of 1964, and the permanent agreements negotiated in the early 1970s dealt with international telecommunications traffic, leaving open the question of purely domestic use. By the early 1970s, the FCC ruled that Comsat Corporation did not have a monopoly over domestic satellites, opening the door for domestic satellite competition. Three companies immediately obliged, Western Union, RCA, and Comsat, collectively placing eight privately owned communications satellites into orbit by 1979. RCA built its own spacecraft, while Western Union and Comsat purchased theirs from Hughes. Cable television became the largest early user of domestic satellites in the US.[57]

Foreign governments also started their own communications satellite programs in the 1970s. Canada started domestic service, forming the government-owned Telesat Corporation, which purchased three Anik-series

of satellites from Hughes, and placed the first into orbit in 1972.[58] Indonesia placed two Palapa satellites, also purchased from Hughes, into orbit in 1976 and 1977. Toshiba, under contract from the National Space Development Agency of Japan (NASDA), purchased its first experimental broadcasting satellite, called Yuri, from RCA, launching it in 1978. The Europeans had several experimental satellites that also launched in the 1970s, the Franco-German Symphonie, the Italian Sirio, and the integrated European OTS and Marots satellites. In the 1970s, the communications satellite business underwent tremendous expansion, with significant increases in private domestic systems in the US, Japan, and Europe, and by the mid 1980s governments all around the world funded domestic and regional systems. The demand for launches generated from these new satellites quickly became a target for states and companies that aimed to make money to launch them into orbit.[59]

European Response and the Collapse of NASA's Space Shuttle Policy

European rocketry prior to Sputnik formed primarily in the United Kingdom (UK), France, and Italy, with Germany staying out of the field due to the legacy of the V-2. In each state, government funding and a mix of government, industry, and academic organizations implementing the work was the norm, just as in the US. National programs mostly focused on military issues, such as the creation of air breathing and ballistic missiles. The UK significantly benefited from American assistance in the 1950s, as the US agreed to help the British develop a ballistic missile derived from the US Atlas. The US government allowed the formation of agreements between US companies Convair and North American with UK corporations de Havilland and Rolls Royce for the airframes and engines respectively. The resulting Intermediate Range Ballistic Missile (IRBM) was known as Blue Streak.[60]

When in the late 1950s the British realized along with their American counterparts that solid propellant missiles were about to make their liquid fueled missiles obsolete, UK leaders decided to convert Blue Streak into a launcher, and furthermore used it as the basis for cooperative programs with their European counterparts. The resulting organization, called the European Launch and Development Organization (ELDO), formed in 1964. The UK supplied the first stage, France the second stage, Germany the third stage, Italy the test satellite vehicle, and the Netherlands and Belgium the ground systems and telemetry. With ELDO funds distributed through the national governments, contractors in each country built the various stages and components for the system, using their own methods and documentation, and

with little direction from the top (i.e., systems integration), and little communication among the various contractors. ELDO, without American assistance until 1972, went from failure to failure, never successfully launching its Europa rockets. It was dissolved in 1974.[61]

American assistance never came, because US policy in the 1960s was to discourage the development of large European rockets that might compete with US launchers. The US helped the UK in the 1950s with missiles, and later worked with the Italians on sounding rockets, but would not assist, through technical know-how or technology transfer, European rocketry. European, and in particular French, indignation at this discriminatory treatment would remain a constant spur to European competition with the US for decades thereafter. However, for science missions, the story was entirely different.

Part of NASA's charter legislation was a provision to promote international goodwill through cooperative endeavors. In consultation with other departments, including DOD, and the Departments of Commerce and State, NASA's international policy emphasized cooperation on NASA science missions, and to a more limited extent, the human spaceflight program. In the latter, participation as part of the spaceflight global tracking network was a prominent element. In the former, bilateral agreements for cooperation in the development and launch of science spacecraft became the norm. To spur cooperation, NASA offered two free launches of science missions to countries and organizations willing to participate by building their own spacecraft. NASA was also willing to assist countries in building their first science spacecraft, sometimes by building the spacecraft "bus" for foreign-built experiments, and in other cases by advising foreign space organizations on engineering and management methods as part of the design review process in preparation for eventual launch on US rockets. Many countries participated in these initial offers, including Canada, Japan, Australia, and European nations.[62]

European scientists and science administrators quickly banded together to create the European Space Research Organization (ESRO) to develop and launch scientific experiments into space. The US offered its two free launches, and for the first two missions, ESRO-I and ESRO-II, worked closely with ESRO personnel to design, test, and launch the spacecraft. European contractor teams hired American companies for parts and services not available in Europe, and to consult on the overall design and manufacturing processes. On ESRO-II, UK prime contractor Hawker-Siddeley had "considerable technical liaison" with TRW, while on the Highly Eccentric Orbiting Satellite, prime contractor Junkers Flugzeug hired Lockheed as a technical and management consultant. During the late 1960s, other cooperative industrial endeavors flourished as well, including Boeing's

1/3 purchase of German firm Bölkow, the joint venture between TRW and Engins Matra called Matrel Corporation, cooperation between North American and Société d'Études de la Propulsion par Réaction, and between Douglas and Sud Aviation. For the later Spacelab program, prime contractor Entwicklungsring Nord contracted with McDonnell Douglas as systems engineering consultant, and hired TRW to assist with software engineering. European contractors formed into long-term working relationships eventually hardening into stable consortia that bid together for contracts, with different companies having new roles on each project. Thus on one project, a British company might be a prime contractor with French and German subcontractors, and on another, the German firm would become the prime, with French and British subcontractors.[63]

European competition with the US focused primarily on economic issues, so it was no surprise that the most sensitive issue between the US and Europe soon became telecommunications. Europeans banded together to form the European Conference for Satellite Telecommunications, or CETS in its French acronym, to negotiate collectively with the US for Intelsat. CETS contracted with ESRO to investigate a communications satellite design, despite the fact that ESRO had no charter for this function. In ELDO, France quickly pressed for a more powerful version of the Europa launcher to place telecommunications satellites into geostationary orbit (GEO). France and Germany in 1967 created the Symphonie telecommunications satellite program, which angered other GETS members who saw their opportunity to build a European satellite disintegrating. Italy retaliated by developing its own communications satellite experiment, called Sirio. The UK figured that military communication satellites were the most useful and likely way to gain American assistance, and started their Skynet military communication satellite program.

The problem for the Europeans was American communication satellite policy, which was to support Intelsat by forbidding any competing networks. The US could exercise virtually complete control by virtue of its monopoly on launch capability. If the US refused to launch a European satellite, then the Europeans had no way to place one into space. Americans, through Comsat, controlled Inteslat in the 1960s, but this was not permanent. The Europeans had won the right to renegotiate the Intelsat agreement and duly exercised it. In the new Intelsat Treaty of 1971, governance of the organization ultimately derived from the votes of each member weighted according to their shares in the organization. The organization recomputed share ownership each year based on actual use starting in 1973. Thus the United States' shares in Intelsat, set at 61% from 1964 to 1969, dropped to 50% in 1973, each year decreasing until by the late 1980s it had leveled off to

around 25%. Another critical feature of the permanent agreement was that unlike the original treaty, it made "regional systems" possible, if coordinated with Intelsat. Even more to the point, Intelsat had no authority to take punitive measures if members created regional systems even without the organization's blessing.[64]

In response to the new Intelsat situation, the US modified its policy somewhat, stating that if Intelsat voted by two-thirds majority to "support" a regional system, then the US would launch the resulting communication satellites. If Intelsat did not endorse a competing communication satellite, then the US would refuse to launch it, unless the satellite was experimental. The test case of the policy was Symphonie. French leaders were convinced the US would not launch it, and hence pushed for the creation of an independent European launch capability. The UK, tired of funding ELDO's failures, was confident that the US would launch European communication satellites, and favored putting money into satellites instead of launchers. NASA, at the behest of the US government, was deliberately ambiguous. Failure to give a concrete assurance to launch Symphonie was sufficient to convince other European governments that they needed an independent launch capability. In the second "package deal" of the European space program that formed the European Space Agency (ESA) from ELDO and ESRO, the French gained approval to develop Ariane, a new European launcher. The British, in the meantime, promoted a maritime communications satellite, ultimately known as Marots, while Germany gained the Spacelab program to learn American systems management techniques. France gambled that the Shuttle would fail to lower launch costs, for if it did, their huge investment in Ariane would be a waste of money.[65]

In this package deal, approved in late 1972, new procedures defined the relationships between member governments, ESA, and its programs, and the various contractors who performed the work. Since governments could not uniformly agree on which programs were most critical, ESA separated its programs into mandatory and optional programs. Mandatory programs included ESA's facilities and management, along with science programs. Optional programs included all others. For these, member states negotiated among themselves to determine the relative contributions of each country. Thus, for Ariane, France took the lead, with significant German and Italian contributions. For Spacelab, German contractors gained the prime contract since Germany was the primary financial supporter of the program. For the maritime satellite, Britain placed the most funds, and a British firm acquired the prime contract. A last critical feature of ESA's Convention was the policy of "just return." Each country was to receive contracts to its national firms in proportion to the amount of funding the country contributed to the effort. Thus, if Italy contributed 10% to Ariane, it expected close to 10% of the

industrial contracts in return. Knowing this, industrial firms worked closely with their own governments and other firms within their consortia to ensure that the contract returns and tasks matched their country's funding contribution.[66]

By the mid-1970s, ESA and NASA were both set on their next major launcher programs, Ariane and STS. The future of the two organizations and their contractors hinged significantly on the technical and economic successes or failures of their respective launch systems. Because both systems were government-funded enterprises, economic success was something almost arbitrarily defined, as the prices charged for launches depended not upon the cost to provide the service, but on the political decisions of the nations involved. In other words, countries could subsidize launchers as much as they wanted, without heed to costs.

For the Shuttle, the US Government Accounting Office (GAO) concluded that NASA need not charge customers the sunk costs of building the launch vehicles and ground facilities. Instead, NASA could charge the average cost of operating the Shuttle fleet. This depended upon the expected flight rates of the Shuttle. NASA's initial estimates of Shuttle costs were about $20 million for a 900-kilogram payload, about 50% less than those charged for an Atlas Centaur launch. By 1984, NASA's price per Shuttle flight was $38 million (in 1984 dollars) based on a 1977 model that assumed the Shuttle would make 572 flights over its first twelve years, an average of 47.7 flights per year. Considering that by the end of 1984, the Shuttle had flown a maximum of 5 times per year, this was sheer fantasy. Changing its policy that year to charge only "out-of-pocket expenses," covering only part of the Shuttle's actual operating costs, and reducing the number of anticipated flights to 311 (which still overestimated what NASA would eventually achieve by more than a factor of three), NASA increased its price to $71 million. This price remained drastically under actual operating costs, but NASA successfully appealed to President Reagan in April 1985 not to go higher than this price because of competition from Ariane.[67]

In the meantime, the Europeans were trying to determine the price to charge for an Ariane launch. Without any hard data regarding what NASA would ultimately charge, European leaders in the late 1970s began with NASA's initial $20 million estimate, and assumed that Ariane's price must be comparable. Like the Shuttle, the Europeans would charge lower prices during an initial "promotion phase" before increasing prices to reflect costs and the competitive situation over the long term. The first opportunity for Ariane outside of ESA launches was the Intelsat V contract coming up in 1978. Since in 1977 Europe for the first time had more votes than the US in the Intelsat Board of Governors, European delegates muscled Intelsat into

selecting Ariane in 1978 for a price of $21.35 million for one launch. This figure corresponded to the marginal cost of fabricating one more launcher in the ESA promotional series, plus launch operations costs.

As the ESA Member States could not agree on how to run the long-term program, in 1979, the French proposed creation of a private corporation to manufacture, market, and launch Ariane. The new company's capital of about $30 million at that time would be 60% owned by French government and private institutions, and the remainder by other European corporations participating in the program. ESA would hand over free of charge all facilities and equipment developed during the Ariane promotion and development phases, and member governments participating in the program would pay through ESA the maintenance and operating costs of the Guiana Space Center launch facilities. The new company, eventually called Arianespace, would pay a sliding fee from 1% to 6% of launch prices for the use of the Guiana Space Center, increasing up until the 31st launch of Ariane. The French government agreed to pay liability damages should launch accidents causing major damage occur. By February 1984, Arianespace decided on a sliding scale from FF 240.9 million for a 1140 kg payload into geostationary transfer orbit (GTO), to FF 443 million for 2500 kg into GTO. ESA and the corporation assumed six launches per year. At these prices they could recoup the full costs to Arianespace, given ESA's separate payment of launch facility maintenance and for the costs of ESA and French national space agency (CNES, Centre National d'Etudes Spatiales) personnel.[68]

NASA found itself in a difficult situation by 1984, as the basis for its Shuttle policy eroded due to its own inability to increase the Shuttle's flight rate, French competition, and increasingly vocal objections of DOD, American launch contractors, and other officials in the Reagan Administration who favored commercial interests. Reagan was more favorably inclined towards space commercialization than his three immediate predecessors. In 1982, Reagan announced support for private sector investments in space, and in 1983, endorsed the idea of a commercial ELY industry. To this end, the administration issued a directive that specified the government would encourage the use of launch ranges, and to sell equipment, facilities, and services at reasonable prices. By 1984, Reagan designated the Department of Transportation as the lead agency for launch vehicle commercialization. The Department soon set up the Office of Commercial Space Transportation to facilitate launch licensing and to act as an advocate for the commercial launch industry. In 1984 as well, Congress passed the Commercial Space Launch Act that secured the position of the Department of Transportation. The idea was to remove NASA and the DOD from their intermediary roles, and to let the ELV industry supply services to government and private customers on a fee for service basis.[69]

Despite these initiatives, the big three ELV companies did not move very quickly to create a commercial industry. NASA and the DOD had always acted as intermediaries, managing launch services for any outside customers, and they remained the companies' primary customers. DOD was officially committed to the Shuttle, although significant dissent to this policy was emerging. NASA was adamantly against changes to its policy of capturing all possible payloads to increase Shuttle flight rates, lower costs, and make ELVs obsolete. Since the Reagan Administration in 1983 had decided to pursue the Strategic Defense Initiative (SDI) and in 1984 decided to pursue NASA's long-envisioned space station, Martin, McDonnell Douglas, and General Dynamics, were not going to risk losing major new business from their main customers. Either NASA or DOD would have to change policies for them to take the plunge into commercial operations.

During this period of uncertainty, Transpace Carriers, Inc. (TCI), founded in 1982 by David Grimes, a former project manager for the Delta launcher with NASA Goddard Space Flight Center, bid to commercialize the Delta, since McDonnell Douglas was reluctant to do so. TCI established a preliminary agreement with NASA that if they could secure three commercial launches and funding, they could proceed. McDonnell Douglas would manufacture Delta for TCI under subcontract if they succeeded. TCI in May 1984 filed suit with the US government against ESA, charging that ESA illegally subsidized the Ariane, and hence that the US government should prohibit marketing or use of Ariane by any American company.[70]

This suit was dangerous for Arianespace, but it was also equally dangerous for NASA. Exposing the subsidies and pricing of Ariane launches would draw protests from the Europeans, which would require an investigation into American practices as well. Grimes knew very well that TCI could not succeed against either of these government-subsidized launchers if their respective governments did not have some pricing limitations. The American and French governments could easily lower the prices of Shuttle and Ariane launches below any profitable price that TCI could offer. Things turned out as expected, with investigations launched by the US government into launch vehicle pricing on both sides of the Atlantic. The episode embarrassed NASA, and shed more light on the arbitrary pricing policy for the Shuttle, and for Ariane as well. Unfortunately for TCI, the Reagan Administration in 1985 ruled that since governments subsidized both projects in significant ways, the French were not violating any rules or industry practices then in existence. TCI lost, but so did NASA.[71]

The foundation for NASA's Shuttle policy was its alliance with DOD, and in 1984 this unraveled. DOD analysts and leaders worried about STS delays, and about what would happen if a catastrophe hit the Shuttle, which

would ground the launch fleet and leave DOD without any means to launch payloads into space, even in a national emergency. They had hoped that commercial launchers might be available, but with the pricing war between NASA and Arianespace, no commercial vendor could compete. When in fall of 1983 a bid by Martin Marietta and Federal Express to launch an Intelsat spacecraft failed as the Shuttle and Ariane both undercut the private bid, DOD's concern became critical. In March 1984, DOD revolted, abandoning its commitment to exclusive Shuttle use, and contracting in February 1985 with Martin Marietta to develop heavy lift Titan IV launchers that could operate in case of STS failures or delays.[72]

NASA's leaders still doggedly hung onto the STS policy. Two new private companies offered to purchase and operate a fifth orbiter, but NASA's negotiators drew a hard line and never came to any agreement. NASA's executives studied, but decided against privatizing operations of the Shuttle fleet for the foreseeable future. Delays in STS flights created a huge backlog of customers that could not get their payloads into space, virtually handing business over to Arianespace. Reagan Administration doctrine created a new office in the Department of Transportation to promote commercial space, weakening NASA's grip on civilian space activities. The TCI suit exposed NASA's arbitrary pricing policy and the inability of any private ventures to compete against a government organization bent on monopolizing the business. Then the DOD abandoned its shuttle-only policy and revived Martin's Titan from the verge of extinction. The final blow was the STS Challenger accident in January 1986, which destroyed one fourth of the shuttle fleet, killed seven astronauts, grounded the fleet for two years, and destroyed NASA's remaining credibility and launch vehicle policy. ELVs were back to stay, and a viable commercial launch business emerged.

END OF COLD WAR AND MULTILATERAL COMPETITION

In the aftermath of Challenger, America's flawed launch vehicle policy, which was based on the premise of a commercial industry competing with its own government, was discredited. The Reagan Administration banned NASA from all commercial launches, restricting the Shuttle to US government launches only, or those few launches where human-tending of the payloads was necessary. The DOD revived its ELV programs with all three major launch vendors, Martin Marietta, General Dynamics, and McDonnell Douglas. General Dynamics and McDonnell Douglas now aggressively pursued private launches, pushing TCI out of the way. With a huge backlog of communications satellites waiting for launchers, NASA competition eliminated, and Department of Transportation ready to issue licenses, the

prospects were bright for the ELV companies. NASA and the DOD fought a rearguard action to control launches as they had in the past, but the Reagan Administration, allying with the Department of Commerce, forced them reluctantly into compliance. After 1988, the government purchase of rides into space became the norm, as opposed to procuring and managing launcher programs.[73]

In 1986, SDI was in full swing, and DOD was preparing to launch all kinds of spacecraft and experiments into space. It needed more launch capability than existed, particularly for small experimental payloads. To meet this need, OSC, Space Services, and other small companies offered proposals for new systems. Of them, OSC's proposal to build an aircraft-launched solid booster in conjunction with Hercules Corporation was the most successful. The Defense Advanced Research Projects Agency (DARPA) funded each of these companies, with the OSC proposal leading to the development of the Pegasus launcher, and eventually the Taurus. OSC was in trouble, because its main product, a Shuttle-compatible upper stage, was grounded along with the Shuttle fleet. DARPA's funding and SDI's demand to launch small payloads saved the company. By the early 1990s, with its launch vehicle businesses succeeding, OSC invested in building a constellation of small communication satellites called Orbcomm for remote messaging, such as reporting remote measurement (for example, oil pipeline information) back to central locations.[74]

Privatization also affected remote sensing. In 1972, NASA launched Landsat 1, built by General Electric. To distribute data, the Department of the Interior established the Earth Resources Observation System (EROS) Data Center near Sioux Falls, South Dakota. Over the course of the decade, the Landsat program gained users of its data in the US and around the world, and in 1978, the Carter Administration turned the system over to the National Oceanic and Atmospheric Administration (NOAA), with the proviso that the system eventually be privatized. The Reagan Administration carried through with the recommendation, and Congress passed the Land Remote Sensing Commercialization Act of 1984, which provided for a temporary government subsidy and transfer of Landsat operations to private industry. Hughes Aircraft and RCA Astro-Electronics formed a joint venture known as the Earth Observation Satellite Company (Eosat). As critics feared, Eosat had to significantly raise prices of the processed imagery, which caused a significant decrease in image use and customers.[75]

Eosat's position might have been easier except for French competition. Seeing the success of the Landsat program and its worldwide clientele, France embarked on another program to break an American monopoly. Launched in 1986, the Système Probatoire d'Observation de la

Terre (SPOT) satellite followed the trail of Ariane. French officials established a privately owned company (a minority of the shares owned by the French government) to market and operate the satellite, known as SPOT Image. The government turned over the satellite and ground systems to the company, so that SPOT Image only had to cover the costs of operating the spacecraft and processing the data. It soon provided stiff competition to Eosat, as SPOT's sensors were in many ways superior to those of Landsat.[76]

Competition from SPOT and other countries that planned to orbit remote sensing satellites, and the end of the Cold War brought about significant changes to US remote sensing policy. The Land Remote Sensing Policy Act of 1992 provided for licensing of American private remote sensing systems accessible by the US government in case of emergencies. Several companies began to develop systems, but technical mishaps and launch failures overtook many of them over the next decade. One exception was the Ikonos spacecraft developed by Space Imaging and launched in 1999. With one-meter panchromatic resolution, Ikonos provided for the first time high-resolution commercial imagery. The US government helped private ventures somewhat with the Commercial Space Act of 1998, which dictated that the US government must purchase commercial images "where appropriate." This policy was contradicted by the government's operation of Landsat 7, which provided imagery at a significantly lower cost than possible by Ikonos or other purely commercial ventures that had to recoup development cost as well as fund ongoing operations. The future of commercial remote sensing spacecraft remains uncertain today. However, by far the bulk of private industry is in enhancement of raw data, also known as the "value-added" industry. The estimated value of raw imagery sold on the market in 2000 was $173 million, yet the value-added industry's value was approximately $3.3 billion in that same year.[77] Of that, only 35% was based on space imaging.

The end of the Cold War in the early 1990s brought a severe downturn in military spending, although space technology funding and operations remained largely unaffected. In the resulting aerospace industry shakeout, aerospace companies took several strategies. Some, such as General Electric, bailed out, selling off its aerospace operations to Martin Marietta in 1993, which took the opposite strategy of acquiring other aerospace businesses to strengthen its grip on the smaller marketplace. Martin also acquired General Dynamics' launch business in 1993, moving Atlas production from San Diego to Denver. In a major coup, it merged with Lockheed in 1994 to become Lockheed Martin. Boeing also strove for consolidation in the space industry, acquiring Rockwell's space business in 1996, and McDonnell Douglas in 1996 and 1997.[78]

Military space spending remained stable in part because of the successful use of space assets during the Gulf War. Without significant

telecommunications infrastructure in the Middle East, communications satellites were essential to coordinate the massive Allied effort. The DOD leased commercial lines, as well as using its own assets. Remote sensing satellites, from Landsat and SPOT to the NRO's highly classified systems, provided essential mapping information, monitored Iraqi troop movements, and assessed bomb damage. Weather satellites kept the Allies abreast of conditions for military operations, and the Defense Support Program (DSP) satellites detected Scud missile launches, relaying their trajectories and targets to waiting Patriot missile batteries. GPS, partly operational in 1990 when Iraq invaded Kuwait, was an essential tool for allied forces in the air, on the sea, and on the ground. With an inadequate supply of receivers available from regular military procurement, the DOD quickly purchased thousands of commercial receivers for its troops. Space assets proved their worth in the Gulf War for those who doubted them, and space budgets after the war remained stable even as other military funds shrunk.[79]

GPS, once deployed, was like a natural resource available for exploitation by any who could find uses for the signals. By 1997, over 300 vendors with over $3 billion in sales were supplying GPS receivers and software for a variety of applications, from trucking, fishing, wildlife tracking, mapping, and aviation. By 2000, GPS revenues exceeded $7 billion. Growing civilian applications presented a dilemma for the Clinton Administration, as the military understandably wanted to keep control of the system and its high precision signals. An increasing number of private companies and government civilian users began to call for open use of the high precision signals, and a guarantee that the US would keep the signal available for civilian use regardless of wartime contingencies. In 1996, the Clinton Administration established the Interagency GPS Executive Board to support civilian uses while safeguarding national security. The Clinton Administration turned off "Selective Availability" in May 2000, providing the high precision signal to all users. The unexpected commercial success of GPS has provoked debate regarding military versus civilian control of the system, and in Europe about creating its own navigation system, Galileo, to compete with the US.[80]

The end of the Cold War and of the Soviet Union also signaled the start of a new era of launch vehicle competition. Whereas in the early to mid-1980s, the US had to concern itself mainly with ESA's Ariane, by the early 1990, the competition for payloads had quickly expanded to include Russian and Chinese launchers. Since most payloads were owned or manufactured by American corporations, the US government could define the policies under which these state-sponsored enterprises could compete for launch services. The US government wanted to support newborn Russian capitalism and

democracy, and with the Russian space industry as one of the few strengths of the Russian economy, the US had to balance protection of its own industries with providing opportunities to integrate the Russians into the capitalist world economy.

The resulting bilateral agreements required the Russians, Ukrainians and Chinese to charge prices akin to what the US launcher companies charge for similar payloads, so that the clamor for launching on Russian and Ukrainian vehicles would not undermine the market for US ELVs. In addition, each country had a certain quota of commercial launches that it could provide, again ensuring sufficient business for the US launch industry. Agreements with Russia and the Ukraine ended in 2000, allowing American companies to purchase launches without restriction from Russian and Ukrainian companies.[81]

Russia's entry into the ELV market was accompanied by US and European corporations, which created joint ventures with Russian corporations to market Russian launchers. This way both US and Russian companies profit, thus promoting political harmony between the two countries. Recent examples include International Launch Services, a joint venture of Lockheed Martin and Khrunichev Energia to market Proton and Atlas launchers; Sea Launch, a joint venture of Boeing, RSC Energia, NPO Yuzhnoye and Kvaerner AS to launch Zenit rockets from a mobile sea platform; Starsem, a French-Russian venture to market Soyuz launchers, and Eurockot, an alliance between the German DASA and Khrunichev to market the Rockot vehicle. American launcher and engine companies now regularly use Russian space hardware in their systems.

These international agreements have succeeded largely because of the continuing increase in demand for launches of communications satellites. By the late 1990s, steady demand for more than thirty communications payload launches per year had evolved, with many countries and private corporations developing or purchasing communications satellites for telephone and data services, direct broadcasting, and a variety of other applications. Demand for new services such as mobile telephone and messaging, and for Internet data services spurred the development of LEO constellations, as opposed to a small number of GEO satellites. OSC and Teleglobe built a system of 28 satellites in LEO for two-way messaging and monitoring, becoming operational in late 1998. Motorola raised and spent $5 billion to develop a constellation of 66 Iridium satellites for mobile telephone services. Qualcomm, which had developed space-based messaging and navigation systems, invested in Globalstar, a constellation of 48 satellites for mobile and stationary phone services. ICO raised $4.7 billion to build a system of 10 spacecraft in medium Earth orbit. And, in another venture Teledesic planned to place 288 satellites into orbit for high-speed data transmission.

This sudden surge of launch demand in the late 1990s caught the attention of entrepreneurs who realized that existing launch companies could not adequately meet the burgeoning demand. Thus, a spate of start-up launch companies opened their doors in the late 1990s to service the anticipated demand, and to create new services such as space tourism. Beal Aerospace began development of a new ELV, but the remainder focused on reusable launch vehicle (RLV) designs. Kelly Space tested a concept for a towed reusable system, while Kistler Aerospace began development of a two-stage reusable system with Russian engines. Rotary Rocket came up with an innovative concept for a "helicopter-style" landing with rotors, while Space Access used a two-stage design with ramjets and traditional rockets. In the US, states developed commercial spaceports to promote the local space industry, including sites in Florida, California, Virginia, and Alaska.

Unfortunately for these new companies, the demand for launches did not keep up. Motorola fundamentally misjudged the mobile telephone market. They went bankrupt in 1999, as did ICO. OSC's Orbcomm filed for bankruptcy protection in 2000; Globalstar did the same in 2001. Teledesic's designs, along with others, remained on paper, awaiting the outcome of legal proceedings. In a harbinger of what is to come, Iridium Satellite purchased the $5 billion Iridium constellation for a bargain basement price of $25 million, and acquired the DOD as an anchor customer in 2000. Following in the wake of the communication satellite bankruptcies, several of the new launcher companies closed their doors. The final outcome of these events and corporate ventures is yet to be determined, but easy success is certainly not the story. Despite these spectacular failures, the global satellite communications market continues to grow steadily, reaching over $67 billion in 2000. Most of the successes have come with traditional GEO satellites.[82]

In the meantime, the Cold War's end affected NASA, as its budget slowly shrank in the early to mid 1990s. Daniel Goldin, NASA's Administrator from the end of the Bush Administration (89) through the eight years of the Clinton Administration and into the first year of the second Bush Administration (01), was under pressure to reduce NASA spending, while continuing its missions of exploration, science, and international cooperation. Goldin had two major budget busters on his hands, the Shuttle and the space station. Congress revived the Shuttle program with the purchase of a replacement orbiter, injunctions to ensure safety, and to keep out of commercial launches. The space station floundered from its initial approval in 1984 until 1992 with various redesigns and reductions as the station's costs escalated far beyond the initial estimate of $8 billion. In yet another review of the station, the Clinton Administration in September 1993 brought Russia in as a partner for the redesigned International Space Station (ISS), adding to the

countries already participating- ESA member states, Japan, and Canada. As with earlier big projects, the major aerospace companies in the US, Japan, and Europe all had various pieces of the project. The first element of ISS was launched in 1998, with construction and operations to continue at least another decade or more.

Faced with the large operating costs of the Shuttle, and the investment required for ISS, Goldin recognized that to keep NASA's other programs productive he needed to reduce their costs, while hopefully maintaining their quality. To do this, he coined the phrase "Faster, Better, Cheaper" to signal new ways of doing business to stretch NASA's resources further. In the design and management of robotic missions, Goldin pressed hard on NASA and its contractors to reduce bureaucracy and paperwork, as well as rely on new technologies, such as artificial intelligence and lightweight structures to reduce operations and launch costs. For this Goldin used the DOD's Clementine mission run on a small budget as a paradigmatic example, to design smaller, more flexible, more frequent missions using technologies derived from the DOD's SDI of the 1980s and early 1990s. NASA chalked up some spectacular successes such as the Lunar Prospector mission run by the Ames Research Center and built by Lockheed Martin and JPL's Mars Pathfinder mission in 1997. However, a rash of Mars probe failures from 1999 to 2001 yielded a backlash in NASA and in Congress, and a return to conservative design and management approaches.

In the Shuttle program, Goldin's initiatives resulted in privatization of Shuttle operations through the formation of a joint venture between Boeing and Lockheed Martin known as United Space Alliance (USA). NASA contracted with USA to perform launch operations, train astronauts, and upgrade the Shuttle. Goldin called for consolidation and privatization of mission operations for the Shuttle and for robotic missions at JPL and Goddard. This resulted in a $3.4 billion contract with Lockheed Martin to automate, consolidate, and maintain mission operations activities. NASA's initial efforts to create a new reusable launcher in partnership with industry failed when the X-33 program, in which NASA and Lockheed Martin each invested nearly a billion dollars, was cancelled due to technical problems, and the lack of a sizable market for Lockheed Martin to privately fund X-33's supposed successor, the Venture Star. Not to be deterred, NASA revamped its reusable launcher program and is currently working with industry to develop RLV concepts that could serve as a Space Shuttle replacement and also meet future commercial interests.

Privatization has affected the international communications consortia as well, due in part to trends in the US, but more importantly due to competition from private sources. Intelsat's board decided to privatize the organization in 2001. Existing stakeholders in Intelsat would become its

initial stockholders, and Intelsat, Ltd. made a public stock offering in late 2001.

CONCLUSIONS

Space business has grown consistently since its beginnings in the 1940s, and in all cases with significant interactions with national governments. Nation-states funded virtually all early efforts, particularly the creation of the first rockets and spacecraft that made the space age possible at all. In the US, negotiated contracts from DOD and NASA were the primary means of doing business, a method that Europeans followed as well. Government managers dictated the needs, provided the funding, and supervised closely the activities of contractors, who through these funds built up the expertise to build the machines that put humanity and its automated agents into space. The government itself operated these systems, launched the rockets and controlled the spacecraft.

Communications satellites were the first to break the mold, with private companies such as AT&T willing and able to build and operate communication satellites to link to its ground communications system. The Kennedy Administration's anti-monopoly stance prevented this course, and the US government intervened, creating active competition to AT&T, and creating a new government-supervised corporation, Comsat, to handle space telecommunications. Comsat negotiated with others on behalf of the US for Intelsat contracts, and with its European partners built up the first semi-private system. In the 1970s the first private communication satellites emerged, along with government-sponsored domestic and regional systems that by the 1990s created a tremendous surge in demand for spacecraft launches.

Government activism perhaps reached its peak with the Shuttle, whose creation required the formation of a government monopoly to replace what private activity there was in launch services. France, leading its European partners, broke the Shuttle's monopoly with its Ariane challenge. Later, France broke the American grip on remote sensing as well, with its SPOT system. DOD and the Challenger accident finally destroyed the ill-conceived "Shuttle-only" policy, which handed the majority of the commercial space launch business to Arianespace. Belatedly the US moved to a commercial launch policy, with the government purchasing launch services from private contractors. These changes came just as the Cold War ended, which brought Russian and Chinese competition into the mix. However, all launch companies benefited from significant government

funding and direct subsidies. No "purely private" launch capability existed anywhere in the world prior to the new launch companies of the late 1990s.

Finally, the late 1990s saw the flowering of private space efforts on a large-scale. The lure of dozens of satellite launches, primarily for commercial telecommunications, brought new entrants into the launch business. In 1997, fueled by the capital investments in communications satellite constellations, GPS ground equipment, and launchers, private investment exceeded government spending for the first time. It appeared that the new era of private space business was at hand, but the bankruptcies of Iridium and ICO, followed by the failure of many of the new launcher companies in their wake, have made it clear that for the time being, space will remain, as it has always been, a cooperative endeavor between government and industry. Nonetheless, it is equally clear that private industry's share of the space marketplace, already greater than half, will continue to steadily grow for the foreseeable future.

14

INTERNATIONAL SPACE COOPERATION

Eligar Sadeh*

INTRODUCTION

The onset of the space age is characterized by international cooperation directed at sharing knowledge among space scientists. This was exemplified by the 1957-58 International Geophysical Year (IGY). The IGY coordinated transnational scientific collaboration between sixty thousand scientists and technicians from sixty-six states under the auspices of the International Council of Scientific Unions (ICSU) to study and assess the Earth's spatial environment from low Earth orbit (LEO).[1]

Because of the IGY experience, a belief in "openly" sharing scientific knowledge,[2] and Cold War foreign policy interests, the National Aeronautics and Space Act of 1958, which led to the establishment of the National Aeronautics and Space Administration (NASA), incorporated international cooperation in its declaration of policy and purpose:

> ...cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof should be conducted and are pursuant to the agreements made by the President with the advice and consent of the Senate.[3]

Work done pursuant to the Space Act includes the expansion of human knowledge related to space, improvements in safety and efficiency of aeronautical and space vehicles, development of space vehicles capable of carrying supplies and living organisms into space, and long-range scientific studies about the cosmos and Earth.[4]

The Space Act established possibilities for a comprehensive agenda of international space cooperation. In 1959, NASA put into practice this agenda with the intent of sharing scientific knowledge. This was accomplished by announcing to the ICSU's Committee on Space Research (COSPAR) that it would assist its members "by undertaking the launching of suitable and worthy experiments proposed by scientists of other countries."[5]

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This led to US-European space cooperation through exchanges of letters of understanding whereby NASA provided launch services in exchange for scientific data gathered by European satellites and instruments.[6]

At the same time, the Space Act seemed to restrict possibilities of cooperation by calling for treaties that require presidential approval and Senate ratification.[7] Upon signing the Act into law, President Eisenhower clarified this provision by stating that "...international treaties may be made in this field, and as not precluding, in appropriate cases, less formal arrangements for cooperation."[8] Less formal arrangements, including letters of understanding, intergovernmental agreements (IGAs), and memoranda of understanding (MOUs), requiring only presidential or NASA-level approval, represent the means by which NASA facilitates international space cooperation.

NASA's international cooperative agreements are not science and technology agreements in the traditional sense. Rather, they are cooperative agreements entered into under NASA's statutory authority for international cooperation provided by the Space Act. On account of the unique goals and practices of NASA's cooperative agreements, they provide for open and free exchanges of science, transfers of technical data and goods, and other features, such as broad mutual wavers for liability, that are not normally part of science and technology agreements. In most cases, aspects of these features are incorporated into the IGAs and MOUs through which NASA commits itself to cooperative space endeavors.

In addition to the use of IGAs and MOUs, there exists formal institution building in space involving regimes, treaties, and conventions. The cases of institutions that are discussed herein include: (1) operating agreements of the International Telecommunications Satellite Organization (Intelsat); (2) international space law regime established by the 1967 Outer Space Treaty; and (3) convention for the establishment the European Space Agency (ESA).[9] There are as well a number of case studies that constitute institutional arrangements based on agreements reached on terms of reference or principles. This has primarily occurred in the effort to coordinate space science missions (e.g., Interagency Consultative Group, IACG) and data policies for Earth observations by satellites (e.g., Committee on Earth Observation Satellites, CEOS).

The historical patterns of international space cooperation are reflected in NASA's policy preferences. NASA was willing to cooperate, but only if potential partners accepted certain policy guidelines.

> *Clearly defined and independent managerial interfaces* that ensure NASA's dominance in political authority and decision-making.

> *No exchange of funds* in which each partner is financially responsible for project elements it develops.
>
> *Distinct technical responsibilities* that retain NASA's control of critical path items and overall system integration.
>
> *Protection of sensitive technology* where arrangements for cooperative projects protect against the unwarranted transfer of technology abroad and maintain technologies critical to NASA to ensure the industrial and economic competitiveness of the US.[10]

International space cooperation is a reflection of foreign policy and functional policy preferences related to economics, technology, and science.[11] The period of détente between the United States (US) and Soviet Union was an outcome of symbolic foreign policy preferences directed at reducing Cold War tensions. Détente resulted in IGA umbrella agreements on space cooperation. An IGA between the US and Soviet Union, concluded in 1972, led to cooperation on the Apollo-Soyuz Test Project (ASTP). In a similar way, the functional interdependence between US and Russian space station programs, formalized in a 1998 IGA for the International Space Station (ISS),[12] reflects US foreign policy preferences in the post-Cold War era.

Functional preferences directed at furthering European industrial autonomy played a central role in the formation of ESA.[13] This drive for autonomy, directed at space-based technologies and large-scale systems engineering management, spawned cooperative projects such as the European Spacelab (ESL), utilized as a microgravity laboratory in NASA's Space Transportation System (STS) cargo bay, and European participation in ISS.

Cooperation based on functional preferences is an important part of NASA's STS and ISS programs. For STS, Canadian development of the robotic arm remote manipulator servicer plays a critical role in the ability of STS to retrieve and deploy payloads in LEO. With ISS, the functional energy block and service module provided by the Russian Space Agency (RSA) and the mini-pressurized logistics modules provided by the Italian Space Agency (ASI) are necessary– in the technological critical path– to the proper functioning of ISS.

In space and Earth sciences, cooperation on a functional basis, such as sharing of scientific knowledge through mission coordination, data exchange and analysis, and hardware development, has been the norm since IGY.[14] The first decade of cooperation, 1959-1969, between NASA and Europe, for example, was based on science. Other examples include the International

Solar Polar Mission (ISPM), renamed Ulysses in 1984, involving a joint NASA-ESA space science mission to study the polar regions of the Sun; the IACG begun to coordinate national missions that studied Halley's Comet and continued for coordinating International Solar Terrestrial Physics (ISTP) missions; and CEOS created to harmonize data acquisition, exchange, and policies for Earth observations by satellites.

The review of international space cooperation that follows is first organized according to intergovernmental space cooperation patterns and then on institutional ones. Specific projects that are scrutinized relate to US-European, US-Japanese, and US-Russian space cooperation. The evolution of international space cooperation and the years when cooperation was initiated are tabulated in Table 14.1. Next, the chapter systematically examines the policy dynamics of space cooperation as it relates to these case studies. This examination identifies the functional and political arrangements of cooperation, and characterizes the type of cooperative outcomes that are realized.

Table 14.1. Historical Evolution of International Space Cooperation.

Cases of International Space Cooperation	Year of Initiation
US-European Cooperation	1958
European Spacelab (ESL)	1973
International Solar Polar Mission (ISPM), Ulysses	1979
US-Japanese Cooperation	1969
US-Russian Cooperation	1957
Apollo-Soyuz Test Project (ASTP)	1972
Multilateral Case Studies	
International Space Station (ISS)	1982
Institutional Cases:	
International Telecommunications Satellite Organization (Intelsat)	1964
International Space Law Regime	1967
European Space Agency (ESA)	1975
Interagency Consultative Group (IACG)	1981
Committee on Earth Observation Satellites (CEOS)	1984

CASES OF INTERNATIONAL SPACE COOPERATION

United States-European Space Cooperation

US-European intergovernmental space relations have historically reflected power asymmetries in NASA's favor. This pattern of cooperation realized NASA's functional policy preferences. In essence, NASA capitalized on a structure of European dependence on the US. This pattern of cooperation eroded over time, as ESA became more capable due in large part to the cooperation with NASA that dependence first caused. As a result, US-European space relations concerning ISS, for instance, exhibit more equitable forms of cooperation in technological hardware contributions and decision-making dynamics.

The US initially promoted international space cooperation with Europe as part of a strategy to recover the loss of prestige linked to the 1957 Sputnik crisis.[15] This strategy involved the demonstration of political leadership among its European allies by engaging them in cooperative space ventures. Space leadership implied that institutional and resource asymmetries in NASA's favor would allow it to insist upon its preferences for cooperation– "clearly defined and independent managerial interfaces," "no exchange of funds," "distinct technical responsibilities," and "protection of sensitive technology"– as preconditions for US-European cooperation. Europe was willing to accept these preferences, very often as a dependent and junior partner, to realize its specific functional preferences aimed at fostering space sciences programs, acquiring large-scale systems management and administrative know-how, and developing applied space technology capabilities.[16]

US-European space relations have passed through four distinct phases: 1958 to 1968; 1969 to 1973; 1974 to 1988; and 1989 to the present. The first phase is characterized by US "tutorship" of Europe that was put into practice by limiting the scope of cooperation on a project-to-project basis. US policy preferences were to avoid large-scale sharing or joining of major research and development (R&D) programs. Instead, NASA focused its cooperative efforts on specific technical and scientific packages that could be exchanged to functionally enhance its space projects.[17]

The initial years of cooperation took the form of bilateral arrangements involving launch services provided by the US in exchange for some form of payload sharing on European scientific satellites. Agreements were reached between NASA and the United Kingdom, Italian, French, and German national space programs. With the institutionalization of a unified European effort in space sciences in 1964, represented by the European Space

Research Organization (ESRO),[18] a series of MOUs were reached between NASA and ESRO. These MOUs facilitated NASA's launch services for a series of ESRO satellites in exchange for scientific results obtained from these missions.[19]

The first phase, 1958-1968, also involved technology transfer. This policy, which was endorsed by US President Johnson in 1966-67, was directed at the development of a European-based expendable launch vehicle (ELV) named Europa.[20] The European Community (EC) began these efforts in 1962 with the creation of the European Launch and Development Organization (ELDO).[21] The willingness of the US to allow for some technology transfer, such as in-flight hardware and technical information, was driven by foreign policy preferences. These preferences were to remedy the "technology gap" between the US and Europe, stimulate economic and industrial growth in Europe, and enhance strategic alliances vis-à-vis the Soviet Union.[22]

The second phase, 1969-1973, is represented by a transition from US tutorship to the emergence of Europe as a "junior" partner in cooperative space activities. A junior partnership implied some degree of autonomy in science and hardware development for the Europeans. The 1969 Space Task Group Report on NASA's post-Apollo space program best articulates this type of partnership:

> ...a substantial raising of sights, interest, and investment in space activity by the other nations able to do so in order to establish a base of major contributions by them; and creation of an attractive international institutional arrangement to take full advantage of new technologies and new applications. The form of cooperation most sought after by advanced countries is technical assistance to enable them to develop their own capabilities. We should move toward a liberalization of our policies affecting cooperation in space activities, should stand ready to provide launch services and share technology wherever possible, and should make arrangements to involve foreign experts in the detailed definition of the future United States space programs and in the conceptual and design studies required to achieve them.[23]

Nevertheless, the European space program remained asymmetrical in resources and dependent on the US in several respects. First, NASA dominated in its financial contributions to cooperative projects.[24] Second, NASA was able, if necessary, to functionally continue proposed cooperative projects and missions without European contributions. Third, Europeans

joining the partnership became dependent on NASA for an important aspect of their future activities in space. To compound matters, US President Nixon never endorsed this Space Task Group Report and reversed Johnson's policy of technology transfer to Europe.

Nixon linked technology transfer to national security policy; technology represented a form of "knowledge" to be closely regulated and controlled. Further, Nixon's preferences progressively shifted towards spectacular US-Soviet cooperative achievements in support of detente, while European importance in the US foreign policy agenda was reduced accordingly.[25] This policy undermined the "technology gap" rationale for technology transfer to Europe. Consequently, a shift in gratuitous launch services to one based on the utilization of US launchers, purchased initially by ESRO and then by ESA, took place.[26]

ESRO and ELDO responded to the call from NASA for post-Apollo cooperation by establishing working groups to analyze the technical implications of European participation in the American space program. European objectives were to redevelop patterns of technology transfer, which previously existed in the 1960s, and to realize a more equitable distribution of responsibilities.[27] Technology transfer was to be brought about through access to all post-Apollo systems and by developing elements technologically critical to STS. An equitable distribution of responsibilities was to be achieved by shared operations and decision-making in systems and technical management. In addition, Europe sought to secure commitments by the US to procure European developed hardware on a permanent basis.

US objectives in this second phase differed markedly from the European ones and resembled NASA's traditional policy preferences for cooperation. They were directed as to avoid a reliance on Europe for the success of STS; maintain systems management and decision-making control; provide for detailed access only to technologies necessary for specific European contributions to post-Apollo programs; retain freedom from any formal political commitment to cooperation given possible financial constraints from congressional appropriators; allow for nominal access to post-Apollo systems on a commercial basis; and uphold the principle of "no exchange of funds."[28]

After presidential and congressional approval of STS in 1972, Europe pursued cooperation with NASA on ESL, albeit within the confines of a junior partnership. From a US viewpoint, ESL was a good candidate for cooperation since it satisfied NASA's policy preferences for cooperation. Though Europe failed to realize any of its post-Apollo policy preferences, there existed a willingness to cooperate on ESL because of a lack of confidence in their (European) own capabilities, especially in large-scale

systems management know-how, and the belief that their technological and managerial capabilities could only be improved through cooperation with NASA.[29]

The transition of US-European space relations from a dependent junior partnership to a "genuine" partnership began in the 1974 to 1988 period and fully took hold in the fourth phase from 1989 to the present. A genuine partnership implies that all partners are "free" and "equal" actors in both authority and decision-making.[30] In practice, this meant that Europe could exercise a certain degree of technological and managerial autonomy in its cooperative dealings. The ability for Europe to function in such a way was reinforced by the development of a more autonomous European space program. This included: successful implementation of ESRO and High Eccentric Orbiting Satellites (HEOS) satellite missions begun in 1964; initiation and development of an indigenous ELV development program (Ariane) in 1973; ESL; development of space science, telecommunications, and Earth observing satellite programs in the 1970s and 1980s; and formation of ESA, from ESRO and ELDO, in 1975.[31] Europe's enhanced space capabilities broadened the potential areas of cooperation with NASA and diminished European dependence on the US space program.

Cooperation in the third phase, 1974-1988, encompassed both space sciences and human spaceflight and involved undertakings with NASA, the Soviet Union, and Japan. In space sciences, cooperation involved the International Ultraviolet Explorer (IUE) for the study of distant galactic phenomena, the International Sun-Earth Explorer (ISEE) to study the solar terrestrial magnetosphere, Hubble Space Telescope (HST) for astronomical observation, and ISPM/Ulysses.[32] ESA's contribution to these programs involved scientific instruments and the development of scientific probes. In human spaceflight, ESA successfully developed ESL and is a major participant in ISS.

Cooperation patterns evident on ISS[33] exemplified Europe's genuine partnership status.[34] The driving impulse for cooperation, from an American standpoint, was a fusion between NASA's long-standing plans for permanent expansion into space and President Reagan's policy of technological resurgence as a superpower summed up in a doctrine of "leadership" of the Western strategic alliance.[35] Leadership was physically manifested in a "core" US space station to which partner elements would be added. ESA successfully countered this doctrine of "leadership" with one of "autonomy."[36] Autonomy was manifested in a European Hermes space plane (this was to serve as an autonomous orbital transfer vehicle), a functionally autonomous Manned Tethered Free-Flyer (MTFF) scientific facility, and ESA's portion of the space station polar platforms for Earth observations. In all of these cases, ESA was to have full management and technical authority.

Although a major redesign of the space station in 1992-1993 in tandem with ESA budget cutbacks during the same period led to the elimination of these programs,[37] ESA's policy preference of autonomy carried over to the reconfigured ISS and other cooperative project areas.

Lastly, cooperation from 1989 to the present deals with the emergence of Europe as an "equal" partner in its cooperative relationships with NASA. An equal partnership indicates symmetry in European technological capabilities, interdependent cooperation outcomes in terms of contributions to critical path technologies and infrastructure components, participation in systems and technical management, and project leadership roles. By the late 1980s, Europe's capabilities in ELV technology, and space science, telecommunications, and remote sensing satellites were not only comparable to that of NASA and the US, but from a commercial standpoint were more successful.[38] In its relations with Europe, the US was faced with prospects of both cooperation and economic competition. This shifted the balance of power between the US and European space programs to one more characterized by mutual interdependence.

The realization of interdependent relations is exemplified by US-European cooperation on both ISS and the Cassini mission to Saturn and its moon Titan. In the ISS case, ASI's mini-pressurized logistics modules and ESA's planned support for propellant resupply and orbital reboost are critical to the program. ESA also became more of an equal partner with respect to the management and decision-making structures of ISS.[39] One example of this surrounds the 1993 redesign of the space station that led to the current ISS. Europe participated in the review process for redesign through a Multilateral Program Coordination Committee, and in the decision that led to the inclusion of the Russians into the program. For Cassini, ESA developed the robotic probe and instrumentation that are both critical in this mission to explore Titan.

Additionally, ESA played a role as lead agency within IACG. The mission concept put forward by IACG to study Halley's comet revolved around complimenting ESA's Giotto probe encounter with the comet. In similar fashion, ESA plays a project leadership role in IACG's coordination of ISTP. ESA's ability to take such a leading role in cooperative space ventures speaks for the degree of mutual interdependence that has developed between ESA and NASA.

European Spacelab

Cooperation between NASA and the European space program was an outgrowth of international and domestic policy preferences. Internationally, the US sought to assert leadership by addressing the "technology gap" between the US and Europe. Domestically, international space cooperation enhanced the versatility and political support of NASA's programs and strengthened its precarious budgetary support particularly in the post-Apollo era. Europe, on the other hand, viewed cooperation as essential in developing autonomous technological capabilities in space and furthering industrial policies.

Given these political incentives, NASA and ESRO began discussing possibilities for cooperation on STS. These discussions examined three possible cooperative options: (1) STS development through subcontracting to European aerospace industry; (2) European space tug with subcontracting to US aerospace industry; or (3) European scientific sortie module for use in STS.[40] NASA's conditions for European consideration of these options were established to ensure that no sensitive or economically valuable US technologies would be transferred to Europe. These conditions included technical items that should not be scheduled as critical nor involve high technical risk, simple technological interfaces, and cooperation for which there would not be a high probability of frequent design changes.[41] These restrictions, in addition to NASA's doubts on Europe's technical and managerial capabilities, precluded the first and second options.[42] On this account, the third option of a scientific sortie module, which represented non-critical path (i.e., functionally enhancing and not functionally enabling) STS hardware, was pursued.

Cooperation on the sortie module, which became known as ESL, was formalized in a 1973 MOU between NASA and ESRO for a "Cooperative Program Concerning Development, Procurement and Use of a Space Laboratory in Conjunction with the Space Shuttle System." Albeit this MOU largely reflected NASA's preferences for cooperation and the structural nature of European dependence on the US, it allowed ESA to acquire critical know-how in large-scale systems management and organizational practices.[43]

NASA received full control of ESL through the transfer of ownership and the first unit was delivered free of charge with a provision in the MOU that NASA would purchase a second unit. At the time, future spacelabs beyond the first two were envisioned. Their construction would have provided a substantial profit to ESA. NASA, due to fiscal constraints and a reduced STS launch schedule, only purchased the second unit as obligated in the MOU.[44] However, the purchase of this ESL unit for $128 million, finalized in a 1980 contract between NASA and ESA, was the largest

financial transaction to that date between NASA and a foreign entity;[45] it also denoted the first departure from NASA's preference for no exchange of funds.

ESL also raised important constraints to cooperation regarding the legality of MOUs in relation to US domestic law.[46] In 1973, the US Air Force planned to build a space laboratory of a similar nature to the European one. It was argued that since the US Senate does not ratify the MOU it was not legally binding. In the US, domestic public law takes precedence over executive empowered MOUs and IGAs. The Defense Appropriations Act of 1973 precluded R&D contracts to foreign entities when indigenous capabilities of a similar nature existed. Despite the fact that this constraint never blocked provisions set forth in the 1973 ESL MOU, the controversy spilled over into other cooperative ventures, as exemplified by ISPM (Ulysses), and weakened European resolve to partake in cooperation with the US as a dependent junior partner.

International Solar Polar Mission (*Ulysses*)

ISPM (Ulysses) was characterized by a number of features that made it favorable for international cooperation. First, ISPM was relatively inexpensive, possessed short R&D and operations life cycles, and utilized known technologies. Second, the mission abided by NASA's preferences involving no exchange of funds and protection against unwanted technology transfer. Third, it focused on a specific aspect of transnational collaboration among scientific communities to explore and study the solar environment in Sun polar orbit. Fourth, ISPM was considered the first cooperative venture where Europe was viewed as a genuine partner.[47]

Despite these favorable conditions for international cooperation, the political dynamics of ISPM were problematic. In 1980, one year after NASA signed an ISPM MOU with ESA, NASA announced, due to budgetary restrictions and delays in the STS program, that the ISPM launch would be moved back from 1983 to 1985. This was followed by further US budget cutbacks effectively canceling NASA's promised ISPM probe.[48] The political repercussions of this decision were far reaching to the extent that ESA considered this cancellation as a loss of confidence in NASA as a partner in international space activities. This outcome raised questions within ESA on the viability of international cooperation between the US and Europe, and on the legal utility of IGAs and MOUs.

ISPM cooperation was undermined by US domestic constraints exacerbated by different legal and budgetary systems in the US and Europe.[49] These constraints are procedural (abrupt policy changes and short-term budget

cycles) and structural (no legal system for forcing compliance with IGA/MOU based agreements) as well as due to the exclusion of ESA from critical funding decisions. Ironically, NASA, which insisted upon non-completion contingencies in its cooperative agreements with Europe due to concerns on European abilities to follow through with their commitments, was unable to honor its ISPM MOU obligation to provide one of the two planned solar polar probes. Additionally, inclusion within the MOU of an "availability of funds clause" that allows domestic law, when in conflict, to supersede international obligations provided legal remedy for NASA's termination of its planned solar polar probe.

An annual appropriations process domestically restricted NASA. In budget requests to Congress in 1980, the House Appropriations Committee, with responsibility for funding NASA, recommended termination of ISPM. These funding constraints were compounded by NASA priorities on other space science missions, such as Galileo and the HST, and the growing costs of STS development. An additional complication was the embargoing of NASA's budget. This did not allow NASA to alter line item expenses for its programs. All these factors led to a budget compromise in 1981 that reduced ISPM funding to a level that forced the abrogation of NASA's planned probe.

Though NASA fulfilled other parts of the MOU (i.e., power units, launching, and telemetry tracking), ESA interpreted the cancellation as a fundamental legal breach of NASA's international obligations. ESA was excluded from decision-making in the US in what was supposed to be an international program between equal partners.[50] This is exemplified by the fact that ESA's Director General was informed about the abrogation only hours before it was made public.

In the US, IGAs and MOUs are not legally binding in domestic law. They are executive agreements that cannot legally bind Congress and in particular, cannot take precedence over statutory requirements for annual budget legislation related to NASA's appropriation bills. In Europe, IGAs and MOUs are equivalent to international treaties that prevail over domestic laws in that they are systematically ratified by national parliamentary systems. For ESA, these types of agreements are binding international agreements sanctioned by all its member states pursuant to ESA's Convention.[51]

Linked to these legal interpretations are differences in budgetary politics. In contrast to the annual budget cycles in the US, ESA's mandatory programs in space science[52] enjoy five-year budget cycles.[53] Clashing legal interpretations and funding procedures have established an imbalance in the level of political commitment to cooperation between the US and Europe.[54] Paradoxically, it is this imbalance that sparked the emergence of more mutually interdependent US-European cooperative space relations.

Given the funds and time committed to ISPM, ESA had no choice but to acquiesce (i.e., proceed with a one probe mission renamed Ulysses).[55] While Ulysses questioned US-European space cooperation, it also reinforced European drives for autonomy in space. ESA's Giotto space science mission to study Halley's comet exhibits this. In light of Ulysses, Giotto, which at first was seen as candidates for cooperation with NASA, was implemented independently by ESA.

The political fall-out over Ulysses resulted in a decade passing (1979 to 1989) before the next MOU between ESA and NASA was concluded in space sciences (e.g., ISTP). One striking feature of the ISTP MOU is the degree of detail it enters as compared to past MOU agreements. This denotes not only a sign of caution being exercised, but also a measure of European autonomy in authority and decision-making.[56] The ISTP MOU addresses funding difficulties, obliges the parties to consult with each other before making any decisions that could affect the project, and allows for joint contingency planning that is "for the benefit of the program as a whole."[57]

United States-Japanese Space Cooperation

Space relations between the US and Japan are typified by a "leader-follow" approach. The US was willing to take the lead on cooperative space relations for foreign policy reasons directed at assisting in Japan's post-war reconstruction and integration into the US-led strategic alliance.[58] Japan, as is the case with ESA, promoted and participated in space projects involving international cooperation with NASA in order to attain indigenous capabilities in space. This was accomplished by following the lead of the US. Japan identified the leader in technological capability (i.e., NASA) and then sought to learn as much as possible from its accomplishments to develop a strong indigenous technological base. In essence, Japan developed its space program by importing off-the-shelf space technology and know-how from the US.[59]

These US and Japanese preferences led to a 1969 agreement between the governments that allowed Japan to work with US industry to transfer selected launch vehicle and satellite technologies. For foreign policy reasons, the US departed from one of its cornerstones of cooperation based on protecting the transfer of important space-based technologies.[60] Even though technology transfer ended by 1978-1979, Japan was able to indigenously develop and build launch vehicles as well as communications and Earth observation satellites.

As with US-European space relations, Japan's more symmetrical space capabilities spawned additional avenues of cooperation with the US in

scientific, Earth observation, public service communications, and human spaceflight missions. For example, Japan cooperates with NASA's Earth Science Enterprise and actively participates in the worldwide global change research effort. Japanese experiments and astronauts have flown on STS and Japan is an integral part of ISS. Regarding ISS, Japan has agreed to develop an experimental laboratory module and to utilize its H-2 ELV for assembly and operations support. Japan is also active in promoting space cooperation for lunar exploration and development.[61]

United States-Russian Space Cooperation

Relations in space between the US and Russia are characterized by an intergovernmental paradigm involving both competition and cooperation.[62] Competition was reflected by Cold War politics where the US sought global preeminence and the preservation of national security in space. Cooperation exists among US and Russian scientific communities.[63] Even in the absence of direct governmental cooperation and in periods of Cold War competition, as both IGY and IACG exhibit, transnational scientific collaboration has been sustained. Operationally, this implied Cold War competition in human spaceflight, space technology, and engineering, and cooperation in space sciences.[64] US-Russian cooperation in space has never existed merely for the sake of cooperation itself; rather, it is a product of compatible policy preferences symbolic of stable and friendly overall political relations.[65]

Cooperative relations in space between the US and Russia evolved over five distinct historical periods: 1957 to 1971; 1971 to 1979; 1980 to 1987; 1987 to 1991; and 1992 to the present. The first period, 1957 to 1971, is characterized by scientific collaboration and the space race. Cooperation was initially limited to international nongovernmental scientific forums such as the IGY and its parent groups, the ICSU and COSPAR.[66] These scientific venues led to a 1962 MOU between NASA and the Soviet Academy of Sciences to implement cooperative programs through joint working groups in satellite-based meteorology, geomagnetism, and communications.[67] Cooperation also existed in the codification of international space law as represented by the 1967 Outer Space Treaty. The US and Soviet Union sought to ensure peaceful scientific cooperation in space that could benefit all humankind as well as to establish a legal precedent of unfettered access to space and "freedom of passage" in space to allow for satellite reconnaissance.[68]

Stable and friendly relations symbolized by a policy of detente earmarked the second period, 1971 to 1979. President Nixon's policy of détente, implemented through the Partial Test Ban, Outer Space, Nuclear

Non-Proliferation, and Strategic Arms Limitation (SALT I) treaties, encompassed US-Soviet cooperation in the areas of science, technology, and space. The US and Soviet Union signed umbrella IGAs for "Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes" in 1972 and 1977.[69] Cooperation involved exchanges of information through the establishment of joint scientific working groups between American and Soviet space scientists with respect to projects each carried on independently. These projects included satellite meteorology, meteorological sounding rockets, research on the Earth's environment, robotic exploration of the Earth space, the Moon, and other planets, and space biology and medicine.[70] Even in the field of compatible rendezvous and docking capabilities, represented by the ASTP mission, there was the joining of human and technological resources on a common endeavor.[71] Both the 1972 and 1977 IGA agreements sanction the sharing of scientific knowledge and forbid technology transfer.

The collapse of détente and the resumption of a Cold War rivalry and US-Soviet antagonistic competition demarcated the third period, 1980 to 1987. Nonetheless, space cooperation persisted.[72] Examples include the satellite-aided search and rescue project (COSPAS-SARSAT) involving cooperation between the Soviet Union, US, Canada, and France, bilateral cooperation with the US in planetary data exchanges, and joint US-Soviet biomedical experiments. Cooperation also took place among the superpowers with respect to IACG.

The scientific and technical coordination that took place under the auspices of the IACG, for coordinating national missions to study Halley's comet, resulted in cooperation that leapfrogged political arrangements at the time. A permanent hot line was established between ESA's European Space Operations Center and the Soviet Institute for Space Research along with a computer link between the ESA center and NASA's Jet Propulsion Laboratory (JPL). Due to political considerations, all data transmitted between the Soviet Institute for Space Research and JPL had to be run through the European Space Operations Center since the US and Soviet Union had no formal state-to-state agreement sanctioning cooperation in space.

The fourth period, 1987 to 1991, is distinguished by a resurrection of formal cooperative intergovernmental relations. With the ascendance of Gorbachev to the position of Soviet Premier and the policies of Glasnost and Perestroika, US-Soviet relations in space resumed the formal cooperative arrangements realized during détente in the 1970s. This entailed a 1987 IGA for cooperation in space that brought back the joint working group structures of the 1972 and 1977 IGAs. Joint working groups were established in space biology, space medicine, Solar System exploration, astronomy, astrophysics, space physics, and Earth sciences.

The most recent period, 1992 to the present, witnessed the dissolution of the Soviet Union and the end of the Cold War. This led to a greater degree of cooperation between the US and Russia than ever before. In 1992, an IGA was signed to continue with and expand the space cooperation that was established in the 1972, 1977, and 1987 IGAs. The 1992 IGA sought to expand space cooperation in such areas as robotic exploration of Mars (e.g., Mars Together 98)[73] and Earth science flight projects.[74]

The pinnacle of US-Russian space cooperation was reached in the invitation to include Russia in ISS. This invitation led to cooperation in human spaceflight involving rendezvous, docking, exchange of astronauts/cosmonauts between STS and the Russian Mir space station, and a contract with the Russian Scientific Production Association (NPO Energia) to study the potential use of the Soyuz spacecraft as an interim crew return rescue vehicle for ISS.[75] The NASA-NPO Energia contract, the first between NASA and a Russian company, was a significant departure from Cold War politics. Suddenly, the American civil space program was directly funding its historical competitor.[76]

US-Russian cooperation on ISS was realized in a 1998 IGA "Among the Government of Canada, Governments of the Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station."[77] This agreement functionally integrated Russia into the infrastructure and critical path of the space station program of NASA and its allies in Europe, Japan, and Canada.

Apollo-Soyuz Test Project

ASTP was the first cooperative human spaceflight mission. Cooperation was a result of political symbolism and functional concerns. Apollo-Soyuz was driven by a convergence of political symbolic norms centered on détente. The project was seen as a foreign policy tool aimed at relaxing Cold War tensions and future areas of potential conflict between the superpowers.

A bilateral IGA served as the vehicle for cooperation on ASTP. In 1970 and 1971, agreements were reached between NASA and the Soviet Academy of Sciences entailing organization of Apollo-Soyuz. These agreements served as the basis for the IGA "Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes" signed by Soviet Premier Kosygin and President Nixon at the 1972 superpower summit in

Moscow. This IGA endorsed a joint working group structure between the respective national space agencies to implement Apollo-Soyuz.[78]

Functional cooperation involved joint working groups of engineers and scientists. These working groups even predated the 1972 IGA.[79] Cooperation took place in the development of an androgynous docking mechanism, coordination of mission plans, science experiments, and data and telemetry tracking requirements. Both countries agreed to design and fabrication details, while hardware development was conducted independently to minimize technology transfer. The docking mechanism served to enhance the safety of human spaceflight by allowing for rescue missions and providing opportunities for conducting joint scientific experiments in LEO.

ASTP took place because both the US and Soviet Union decided that they could realize important policy preferences in a cooperative endeavor. For the US, ASTP enabled a firsthand look at Soviet capabilities in space, served as an important policy bridge for NASA between the ending of the Apollo era and start of the STS program, and allowed for the siting of Earth remote sensing photographic equipment. The Soviet Union viewed ASTP more in symbolic terms. Foremost, ASTP implied that the Soviet space program was comparable to NASA's in its technological capabilities and know-how.

International Space Station

NASA's space station program has evolved over three distinct phases of cooperation. The first phase, 1982 to 1983, dealt with coordination of mission concepts. From 1982 to 1983, NASA, European, Japanese, and Canadian space agency experts discussed plans for a space station although no respective government had approved such a program.[80] In May 1982, without any formal commitment for a space station on the part of the US President or Congress, NASA established a Space Station Task Force. The Task Force provided focus for NASA's space station activities that involved conceptual definition studies and mission utilization plans. Studies and plans were conducted within NASA and coordinated among the international partners under the auspices of an International Cooperation Working Group (ICWG).[81] The ICWG involved scientists and engineers within NASA that interacted transnationally with their counterparts in Europe, Japan, and Canada. For instance, Europe initiated space station utilization studies in parallel with the Space Station Task Force in June of 1982, and Japan's National Space Development Agency (NASDA) agreed to commence studies in July of 1982.

The second phase of cooperation, 1984 to 1988, entailed agreements on a multilateral IGA and bilateral MOUs between NASA and its foreign partners. In 1984, President Reagan directed NASA to develop a space station and to "invite other countries to participate so we can strengthen peace, build prosperity and expand freedom for all that share our goals."[82] The European, Japanese, and Canadian governments responded by publicly stating their commitments to participate. These initiatives were followed by a four-year period of negotiations (1984 to 1988) on an IGA/MOU framework of cooperation.

Similar to ISPM (Ulysses), different interpretations regarding IGA and MOU legalities became a factor during negotiations. This led ESA to insist upon a single multilateral IGA even though NASA preferred separate MOU bilateral arrangements.[83] Eventually, a compromise was reached as both a multilateral IGA among the US, Europe, Japan, and Canada, and a series of bilateral MOUs between NASA and its foreign partners were agreed to.[84] It is this combined multilateral-bilateral arrangement that has served as the basis for cooperation throughout the space station program. This partnership was characterized by an asymmetry in NASA's favor. Foreign partners were dependent on NASA for a major aspect of their future human activities in space since their specific elements could not function without being attached to NASA's "core" station.[85] The IGA and MOU agreements abided by NASA's policy preferences with respect to no exchange of funds, clean technology interfaces, control of critical path items, and protection of sensitive technologies.

Domestic policy preferences rooted in the incremental nature of US congressional budgetary politics also influenced international cooperation.[86] Without involving its partners directly in the decision-making process, congressional appropriators forced NASA, from 1986 to 1993, to redesign the space station several times because of rising costs and less than expected funding. Domestic budget constraints forced NASA to cut costs by reducing redundant contributions among partners. Ironically, this mitigated the extent to which NASA was able to remain independent of its international partners for the completion of the station. This, in turn, enhanced the program's interdependence. In addition to NASA's dependence on the Canadian mobile servicing center for assembly and operations, the program became dependent on ASI's mini-pressurized logistics modules for getting cargo to and from the core station. NASA, as part of a 1993 redesign, abandoned its earlier plans to develop such modules.

The third phase of cooperation emerged in light of the dissolution of the Soviet Union in 1991-1992. As a result, the station became symbolic of post-Cold War politics signified by enhanced US-Russian cooperation in world affairs. Russia became politically and functionally incorporated into

the space station program. In the course of incorporating Russia, NASA departed from its traditional policy preferences of cooperation.[87] The US authorized the transfer of NASA funds contracted out in Russian goods and services for space station hardware. Also, Russian contributions are in the critical path items of what is now a NASA-Russian "core" station. Moreover, Russia is substantially involved in early assembly and provides critical path infrastructure elements on which the partnership depends throughout the program. The degree to which there is cooperation over the technological critical path is illustrated in Figure 14.1.

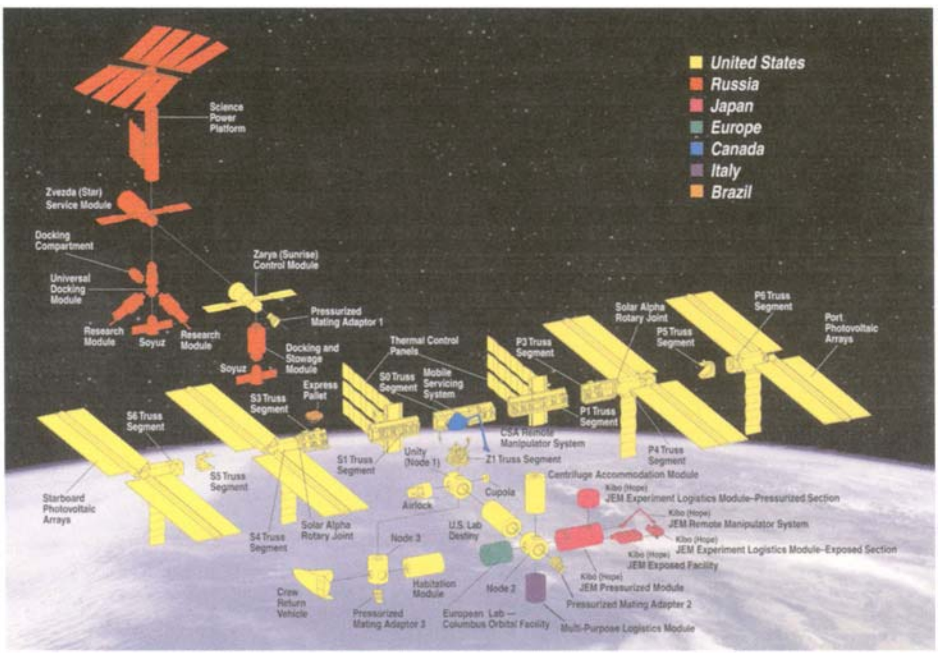

Figure 14.1. International Space Station Hardware Responsibilities.
Source: Boeing.

International Telecommunications Satellite Organization

The objective of Intelsat is to provide, on a commercial basis, the space segment for public telecommunications services.[88] This includes satellites required to support the operation of spaceborne telecommunications. Intelsat was established as an international consortium in 1964 on the basis of Interim Arrangements, and in 1971 through Definitive Arrangements for the regulation of telecommunication satellite systems.[89]

Through Intelsat, the US sought to realize international and national preferences. International preferences were directed at "the American crusade on behalf of space for the benefit of all mankind."[90] National preferences were concerned with maintaining technological and commercial leadership in telecommunications satellite development. The US wished to preserve its technological advantages in this new commercial sector, while ensure that the benefits of communicating via satellites were available to all countries whatever their stage of economic development.[91]

Intelsat was initially established under the auspices of a US government-owned Communications Satellite Corporation (Comsat). From 1964 to 1980, Comsat managed and effectively controlled Intelsat. Comsat was a majority shareholder initially controlling 61% of Intelsat investment shares with the stipulation that in the future, as Intelsat inevitably would expand its membership, the US share must not fall below a majority (50.6%).

The transformation of Intelsat into a more distributed international organization (IO), characterized by institutional patterns of cooperation and more equitable distributions of resources, occurred in the 1970s as membership expanded from 15 to 116 states and telecommunications satellite technology diffused worldwide. This institutional genesis is based on the notion that the state acting unilaterally is increasingly dysfunctional in coping with complex technology.[92] The commercialization of telecommunications throughout the world and economic competition that ensued mollified against continued US (and Comsat) dominance over the organization.

Intelsat was institutionalized as an IO based on an Operating Agreement reached in 1971. This agreement established Intelsat as an economic club with commercial firms and state-governments as members.[93] Members pay fees according to their investment shares and utilization rights; investment shares equal a member's allocated percentage of utilization of Intelsat's space segment. Investment shares and utilization rights are allocated through a weighted decision-making system. The terms of Intelsat's Operating Agreement represented a power shift to multilateral authority and decision-making patterns. Accordingly, the US investment share through Comsat, since 1988, has been at the 20 to 25% level.

The US crafted Intelsat to suit its global policy preferences. Over time, the economic and technological changes that took place in telecommunication engendered a greater degree of compatible preferences between the US and other states throughout the world that led to more equitable distributions of telecommunication resources through Intelsat. These trends led to the multinational privatization of Intelsat in 2001.[94]

International Space Law

The Soviet launching of the first Earth orbiting satellite in 1957, Sputnik, created an international legal problem related to sovereignty in outer space.[95] This problem led to evolution of an international space law regime. The regime was based on tacit acceptance of the "Sputnik precedent." This precedent is an accepted principle among states officially recognizing free access to and unfettered passage through outer space for peaceful purposes.[96] Codification of this precedent began in the United Nations (UN) system with the establishment of the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) in 1958.

A UNCOPUOS-sponsored General Assembly resolution of 1961 recognized the applicability of international law and the UN Charter to space, and was the benchmark of the first major achievement in US-Soviet space cooperation.[97] This was followed by additional resolutions that banned nuclear weapons from space, and advocated principles for international cooperation and peaceful uses of outer space. These resolutions were formalized in a 1967 "Treaty on Principles Governing the Activities of States in the Exploration and Uses of Outer Space, Including the Moon and Other Celestial Bodies" (Outer Space Treaty).

The Outer Space Treaty is a hallmark of institutional cooperation in that it takes into account the welfare of humanity rather than the sovereign preferences of states.[98] This Treaty is the basic framework for cooperation on international space law. It incorporates a number of principles that include:

> The exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind.
> Outer space shall be free for exploration and use by all states.
> Outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation or by any other means.
> States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner.
> The Moon and other celestial bodies shall be used exclusively for peaceful purposes.[99]

Since ratification of the Outer Space Treaty, international cooperation on space law has resulted in the Rescue and Return of Astronauts Treaty

(1968), International Liability Convention (1972), Convention on Registration of Objects Launched into Outer Space (1975), and Moon Agreement (1979). This body of international space law is considered an institutional legal regime that fundamentally guarantees free and unfettered access to space.

The Moon Agreement is the last of a first generation of international space law. Concomitantly, it has proven to be the most difficult in terms of securing international acceptance; it has only been ratified by eight states and among them no major spacefaring power. The Moon Agreement seeks to address the question of private property rights on the Moon and other celestial bodies.[100] In this Agreement, the Moon is designated as the common heritage of mankind that forbids ownership of lunar resources by states or non-state entities. The Agreement seeks to establish an international regime to govern exploitation and development of lunar resources once technically feasible. Over these issues of ownership, exploitation, and development, the further evolution of space law continues to be problematic. This was due to the interpretation that the Moon Agreement represents a disincentive (because of the commons designation and international control through a regime) to the development of lunar resources.[101] Sovereign concerns over economic and technological development have until now prevented international acceptance of the Moon Agreement.

European Space Agency

ESA is unique in the annals of international cooperation in that it is the only multinational space agency. The origins of ESA date back to ESRO and ELDO. ESRO, in particular, fostered collaboration in space sciences among European scientists and national space agencies. Such cooperation served as the basis for the formation of ESA in 1975 and ratification of the ESA Convention in 1980. Strong political support for ESA is linked to governing principles that focus on space sciences, multilateral decision-making processes, and equitable geographical and industrial distributions of space technology and development projects.

The ESA Convention establishes an institutional legal framework requiring all member states to participate and contribute funds to mandatory scientific and technological research projects.[102] This has encouraged a high degree of involvement and collaboration among European scientists. ESA manages technical and scientific aspects of mandatory programs through a Science Program Committee (SPC) composed of member state delegates with competence in scientific matters. This community provides for common facilities, such as launchers, telemetry tracking and operations, and has authority over mandatory space science projects. A supranational legislative

council composed of member states establishes political approval and funding levels for these projects. These projects are protected from unwanted changes by requiring a two-thirds majority in council to change decisions.[103]

The concepts of mandatory and gross domestic product (GDP) based contributions, which safeguard ESA programs from national political pressures, are important to cooperation. Programs are driven primarily by scientific merit, and secondarily by political and industrial considerations. This is reinforced by the close working relationship that exists between European space science communities and the SPC.

As ESA's science policy is structured to serve the scientific community independent of political interests, ESA's industrial policy is arranged to share economic and technological resources in an equitable fashion. "Juste retour" (just return) is the mechanism that governs industrial policy. This is measured through an industrial return coefficient that is calculated as the ratio of all contracts placed by ESA in the space industry of a given member state to the budget that ESA spends on projects as a whole. Just return has had a positive effect on political support for ESA activities since it has developed competencies in member states where the industrial capacity is not sufficient to meet return levels.[104]

The ESA model of international cooperation works because it coordinates and balances the policy positions of various European national space programs such as French autonomy concerns exemplified by the Ariane with German and Italian preferences for cooperative projects with NASA. ESA's ability to coexist with Europe's various national space programs lies with the restriction of its funding to common facilities, the preservation of independence for space science research groups, where space science experiments are financially supported by national space agencies, the distribution of resources in an equitable fashion, and the provision of optional programs in such programmatic areas as human spaceflight, Earth sciences, telecommunications, and remote sensing.[105]

Interagency Consultative Group

The IACG was established in 1981 as a multilateral organization involving European, Japanese, Soviet, and US scientists and their respective national space institutes and national space agency representatives. Its mission goals, which were successfully realized, were to coordinate nationally approved missions to rendezvous with and scientifically study Halley's Comet. This success is attributable to several factors: concern with coordinating space science observations of Halley's Comet that were already

approved by national space agencies; mission goals that were specific and well-defined scientifically; and a maximum of informality and a minimum of bureaucracy in that communities of space scientists dominated the cooperative process.[106]

Participating scientists within IACG conceptualized a "Pathfinder" mission coordination concept that allowed for the optimization of mission objectives for each national spacecraft that encountered Halley's Comet.[107] This placated sovereign concerns over authority and decision-making since Pathfinder was desirable for scientific enhancement, but not functionally enabling to individual national spacecraft. The IACG focused on coordination of science to the exclusion of augmented or integrated hardware development that would necessitate some degree of technology transfer. These aspects are reflected in IACG terms of reference including no technology transfer, no exchange of funds, and an advisory role to member space agencies. On this basis, the IACG was able to function as a viable multilateral organization that reinforced historical patterns of collaboration in data exchange and analysis prevalent in space science missions since IGY.

Annual meetings of the IACG were held from the group's formation in 1981 to mission implementation in 1986. These meetings were informal with delegations composed of senior scientists and managers from ESA, Japanese Institute for Space and Astronomical Science, Soviet Institute for Space Research, and NASA as well as professional astronomers from the International Halley Watch.[108] Transnational alliances of space science communities dominated the IACG. The people who were involved for the duration of the Halley mission were by no means strangers, rather they were international colleagues who had collaborated and shared information on various projects through international conferences on space.[109]

The success of IACG was viewed as a compelling reason for the organization to extend its duration.[110] This took place through coordination of solar terrestrial science programs (i.e., ISTP) underway in ESA, Japan, Russia, and NASA. However, this second phase of cooperation has proven to be problematic for the IACG. The expansion of the IACG, due to the size and complexity of coordinating numerous satellites and quadrilateral (Europe, Japan, Russia, and US) coordination for solar terrestrial science, caused the group to become less an informal community of scientists and more a formalized bureaucracy. However, the IACG is deficient in the requisite organizational mechanisms like a formalized organizational charter specifying decision-making procedures and distributions of financial resources. This has resulted in a level of commitment that is not commensurate with the task at hand for ISTP.[111]

Earth Observations from Space

International cooperation, pertaining to Earth observations by satellites directed at assessing global environmental change, is a result of institutional bargaining. This collaborative bargaining milieu for global change science is more explicitly charted in Table 14.2. Collaboration has taken place among state-governments (e.g., US Global Change Research Program) and national space agency Earth observation offices and programs, nongovernmental organizations (e.g., International Council of Scientific Unions, World Meteorological Organization), intergovernmental organizations (e.g., UN Environmental Program, Intergovernmental Oceanographic Commission), and "Earth science" communities within, for example, NASA and other participating national space agencies, International Geosphere-Biosphere Program, and the UN World Climate Research Program.[112] Coordination among these organizations for spaceborne global change research has primarily taken place through CEOS.[113]

The goal of this collaborative milieu is to advance scientific knowledge of the Earth's environment to understand and predict human-induced and natural global environmental change phenomena. Science serves as the end, while politics, a broad-based institutional structure of states, IOs, and scientific communities, provide the means. One of the crucial factors in this case of international cooperation is the ability of transnational networks of Earth scientists to work together in analyzing global change data and to translate those analyses into policy relevant actions. This involves both mission coordination and addressing data policy issues dealing with conditions and access to data, data pricing, periods of exclusive data use, and data archiving.[114] In this regard, cooperation is to ensure that observations will be available to meet scientific and operational needs as well as satisfy data access and data exchange requirements for all parties as effectively and economically as possible.

Cooperation is influenced by political considerations concerned with data policies, national sovereignty, and national security issues.[115] The existence of disparate and incompatible data access polices among various satellite types and programs is reinforced in the retention of by data producers, the requirement of licenses to use data, and the pricing of data above marginal costs of fulfilling user requirements.[116] Harmonizing policies over these issues is one of the most difficult hurdles to surmount in fashioning international cooperation. If cooperation is not to be precluded, advocates of both "all users must pay for profit" and "government development for public benefit" approaches must be reconciled.[117]

Table 14.2. Global Change Science Collaboration.

Level of Activity	Political Actors
Subnational *(United States)*	American Meteorological Society (AMS); American Geophysical Union (AGU); Center for Global Change; Electric Power Research Institute (EPRI); Environment Defense Fund (EDF); Federation of American Scientists (FAS); Global Tomorrow Coalition; National Academy of Sciences (NAS); Goddard Institute for Space Studies (GISS); National Center for Atmospheric Research (NCAR); Natural Resources Defense Council (NRDC); National Climatic Data Center (NCDC); Physicians for Social Responsibility (PSR); Sierra Club; Union of Concerned Scientists (UCS); World Resources Institute (WRI); Worldwatch Institute.
National *(United States)*	**US Global Change Research Program (USGCRP)-Subcommittee on Global Change Research (SGCR)** Department of Agriculture (USDA); National Oceanic and Atmospheric Administration (NOAA); Department of Defense (DOD); Department of Energy (DOE); National Institute for Environmental Health Sciences (NIH); US Geological Survey (USGS); Department of State; Environmental Protection Agency (EPA); National Aeronautics and Space Administration (NASA; National Science Foundation (NSF); Smithsonian Institution (SI).
Transnational	Greenpeace; International Council of Scientific Unions (ICSU); International Geosphere Biosphere Program (IGBP).
International	UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS); UN Conference on Environment and Development (UNCED); Economic and Social Commission of Asia and the Pacific (ESCAP); UN Education, Scientific and Cultural Organization (UNESCO); UN Environmental Program (UNEP); Food and Agricultural Organization (FAO); UN Framework Convention on Climate Change (UNFCCC); Intergovernmental Oceanographic Commission (IOC); World Climate Research Program (WCRP); World Commission on the Environment and Development (UNWCED); World Meteorological Organization (WMO).
Cross-Level *(National, Transnational & International)*	**Committee on Earth Observation Satellites (CEOS)** Global Climate Observing System– ICSU, UNESCO, UNEP, IOC and WMO Global Ocean Observing System– ICSU, UNEP and WMO Global Terrestrial Observing System– ICSU, UNESCO, UNEP, FAO, & WMO Intergovernmental Panel on Climate Change (IPCC)– UNEP and WMO

CEOS was created in 1984 to coordinate data management and policy issues for all spaceborne Earth observation missions.[118] Membership in CEOS is open to all international and national organizations responsible for Earth observation satellites currently operating or in development phases.[119] The primary objectives of CEOS are to: optimize the benefits of spaceborne Earth observations through cooperation of its members in mission planning and in the development of compatible data products, formats, services, applications, and policies; aid both its members and the international user community through international coordination of spaceborne Earth observation activities; and exchange technical information to encourage compatibility among the spaceborne Earth observation systems.[120]

CEOS data exchange principles have been adopted for global environmental change research use and for operational public benefit use with the agreement to make data available to each member in these user categories with no period of exclusive use and on a non-discriminatory basis. There is a commitment to provide data at the lowest possible cost to bona fide researchers and to harmonize and preserve all data needed for long-term global change research and monitoring.[121]

The concern with sovereignty has been that Earth remote sensed data undercuts the ability of the state to control knowledge both in its creation and application.[122] One important sovereignty concern is the proliferation of commercial remote sensing systems. The US government, ESA, and other states promote commercialization of spaceborne remote sensing.[123] This gives rise to knowledge diffusion and "sovereignty bargains." Such bargains, which promote cooperation, exist when states cede on aspects of their sovereignty (i.e., allow their territories to be remotely sensed) to get the benefits of sharing in the knowledge of Earth observation data.[124]

National security issues surrounding Earth remote sensing emanate from the proliferation of high-resolution commercial satellite imagery. This is especially of concern given the events of 11 September 2001 and the ensuing global war on terrorism. Proliferation of high-resolution imagery has potential security repercussions and may degrade international cooperation and stability in a number of ways. First, increased certainty of an adversary's capabilities may negate the foundation for deterrence. Second, there is the possibility of misinterpretation and international deception leading to shifts in balances of power and even conflict. And third, asymmetrical access to satellite imagery and processing capabilities could provide substantial advantages for some countries over their neighbors (e.g., developed countries over developing ones) with potentially destabilizing effects to cooperation.[125]

Earth observed data gathered by security based reconnaissance systems have also played a role in international cooperation related to

assessments of global environmental phenomena. The US Department of Defense (DOD) has identified its reconnaissance systems as useful for planetary management.[126] In 1991, DOD initiated a Strategic Environmental Research and Development Program and has since established an office for environmental security. The intent is to use military space satellite systems to deal with problems of instability, ethnic tensions, and violent conflict that may have at their base environmental factors. An additional example of military reconnaissance data that been used to advance cooperation involved a group of Earth system environmental scientists that were given in 1998 access to classified satellite data to study global change.[127]

DYNAMICS OF SPACE COOPERATION

Present State of Knowledge

There are analytical shortcomings in the current literature of international space cooperation. Primarily, there are few systemic evaluations that explore the dynamics of cooperation (i.e., the attempts to search for distinctive and systematic patterns of cooperation). In this section, a typological framework for assessing intergovernmental patterns of space cooperation, based upon systematic approaches that have been put forward in the literature, is applied to examine the historical cases of cooperation examined earlier.

One approach in the literature considers how political actors cooperate to realize their policy preferences.[128] International space cooperation is a reflection of both symbolic and functional preferences. Symbolic preferences are political in character, encompassing a range of domestic and foreign policy concerns such as prestige, propaganda, policy legitimization, enhanced policy influence over other actors, international accountability, world leadership, and national security. Functional preferences pertain to economics, technology, and science. Economic interests include maximizing national economic benefits, promoting industrial autonomy, enhancing economic competitiveness, and realizing economic savings through cost burden sharing with other political actors. Technological and scientific interests deal with enhanced capabilities and knowledge gains that can be realized through cooperation.

The political actors that act upon these preferences range from state-governments, their respective national space agencies, and IOs, which include nongovernmental groups like epistemic (i.e., knowledge-based) communities of scientists or engineers. There are three responses for political action: national response where states (i.e., national space agencies) seek to conclude

bilateral or multilateral cooperative arrangements outside any institutional or organizational framework; institutional response where IOs are formed on the basis of some type of multilateral agreement; and mixed response involving both national and institutional responses.

A second approach characterizes four types of space cooperation outcomes.[129] These types include: coordination, augmentation, interdependence, and integration. Coordination involves separate but shared programs. Shared programs imply that separate projects with independent capabilities are coordinated technically and scientifically in some complementary manner. Augmentation is signified by functional enhancements of capabilities through contributions to a national project, which are not on the technological critical path for the mission as a whole. Interdependence entails cooperation that is functionally enabling for a particular project. This implies cooperation on technological critical path and infrastructural systems. Integration denotes joint and shared R&D with the pooling of financial resources.

A third approach specifies how political actors bargain and negotiate (i.e., strategically interact) to realize international space cooperation.[130] Strategic interactions are described by structural conditioning, convergence of norms, institutional bargaining, and epistemic community models. "Structural conditioning" happens when a powerful state-government entity (e.g., national space agency) extends cooperative benefits to others. This process is "structurally" generated because a dominant national space agency influences others, on the basis of an asymmetric distribution of resources (institutional capabilities) and knowledge (science and technology) in its favor, to adopt cooperative policies that are congruent with its preferences. "Convergence of norms" represents an emergence of compatible preferences between political actors as a result of changes that take place in national or international policy milieus. "Institutional bargaining" is a factor of functional interdependence between state-governments. This interdependence is managed through institutions or regimes that establish principles, rules, or conventions. An "epistemic community" model focuses on collaboration between groups of scientists. Space science and Earth science missions are uniquely suited to such cooperative patterns due to their scientific context. This can result in the acquiescence of national decision-makers to epistemic communities in the cooperative policy process.

Dynamics and Outcomes

Dynamics of cooperation can be determined by considering functional and political arrangements that exist in space cooperation. It is assumed that these arrangements are framed by an interplay between interdependence, the reliance upon others for performance of specific tasks, and the desire to keep such interdependent relations to a minimum.[131] States seek to minimize interdependencies by maintaining control of cooperative missions. This pattern of cooperation is reflected in NASA's policy preferences for international cooperation involving distinct technical responsibilities, protection of sensitive technologies, and independent managerial interfaces.

Given NASA's concern about technical responsibilities and protection of sensitive technologies, technological and scientific resources are relevant dynamics of cooperation. There are two distinct dimensions to these dynamics: transfer of technology including systems management and engineering know-how; and control of scientific knowledge dealing with intellectual property rights. Policy preferences regarding technical and managerial interfaces suggest that authority and decision-making patterns are of consequence as dynamics of cooperation as well. Authority deals with who has control over decision-making, while decision-making pertains to the structure of managerial interfaces.

An exploration of how the range of actors, preferences, and political responses relate to specific outcomes identifies additional dynamics of cooperation. This link between what can be termed process– interactions among political actors, preferences, and responses– and outcomes can be conceptualized by considering how the four models of strategic interactions, present in the literature, relate to cooperation outcome-types also present in the literature.

The coordination outcome is characterized by a number of interactions encompassing convergence of norms, institutional bargaining, and epistemic community processes. This implies that coordination is based on a dynamic of compatible functional preferences between national space agencies that are realized through either institutional arrangements or epistemic collaboration. The augmentation outcome is a factor of structural conditioning. This suggests that a powerful national space agency, such as NASA, brings about cooperation through resource and knowledge asymmetries in its favor. Cooperation of such a nature is influenced by the dynamic of NASA's functional policy preferences. The interdependence outcome is a function of convergence of norms. In this instance, compatible symbolic and functional policy preferences create a dynamic of an interdependent multilateral relationship.

The integration outcome is indicative of institutional bargaining. This denotes that joint R&D and the pooling of financial resources require institutional arrangements. What makes integration different from coordination is the extent of institutionalization. Integration, given its level of functionally interdependent relations, pertains to formalized institutions that codify rules and procedures in a convention or treaty. This attests to a dynamic of compatible and shared preferences among cooperating partners, whereas coordination is ad-hoc and focused on a single mission. Institutional arrangements realized through coordination are often engendered by epistemic collaboration and only specify general principles or terms of reference that cooperating partners make their best efforts to endorse.

Technological and scientific resources together with authority and decision-making patterns were identified as dynamics of importance to the functional and political arrangements that characterize international space cooperation. The way in which models of strategic interactions relate to outcome-types indicates that functional and symbolic policy preferences, and the extent to which they are compatible or shared among political actors, play a fundamental role in differentiating cooperative outcomes. Table 14.3 summarizes these dynamics of international space cooperation.

Table 14.3. Dynamics of International Space Cooperation.

Functional Arrangements	**Political Arrangements**	**Policy Preferences**
Technological Resources: Technology Transfer	**Authority Patterns:** National, Institutional	**Functional Preferences**
Scientific Resources: Intellectual Property Rights	**Decision-Making Patterns:** Bilateral, Multilateral	**Symbolic Preferences**

Cooperation Outcomes

The classification of historical cases, reviewed earlier in this chapter, according to the four cooperation outcome-types discussed above is listed in Table 14.4. Coordination and augmentation are predominant types of outcomes since they allow for the realization of policy preferences as valued

by national space agencies. These outcomes are appealing for NASA because distinct political, economic, and technical arrangements can be fashioned, and technology transfer can be minimized.

Table 14.4. Classification of International Space Cooperation Outcomes.

Case Studies (year of cooperative agreement)	Outcome-Types
International Space Law Regime (1967)	Coordination
International Telecommunications Satellite Organization (Intelsat) (1971)	Integration
Apollo-Soyuz-Test Project (ASTP) (1972)	Augmentation
European Spacelab (ESL) (1973)	Augmentation
European Space Agency (ESA) (1975)	Integration
International Solar Polar Mission (ISPM), Ulysses (1979)	Augmentation
Interagency Consultative Group (IACG) (1981)	Coordination
Committee on Earth Observation Satellites (CEOS) (1984)	Coordination
International Space Station (ISS) (1988 and 1998)	Augmentation Interdependence

Coordination and augmentation are reflected in mixed and national responses to cooperation. A mixed response takes place with coordination and indicates institutional arrangements among national entities and epistemic communities; and a bilateral national response, which occurs with augmentation, means the exclusive and direct involvement of state-governments and their national space agencies. Responses vary from agreements on multilateral terms of reference and principles for coordination to bilateral exchanges of letters, MOUs, and IGAs for augmentation.

Functional and symbolic policy preferences can engender a departure from coordination or augmentation. Interdependence, which runs counter to preferences that NASA has traditionally held, is a product of symbolic preferences rooted in foreign policy and functional preferences related to managing complex systems. One important case of an interdependent outcome is related to Russian involvement in ISS. Integration outcomes are reflected in both Intelsat and ESA.[132] For these cases, joint R&D and the aggregation of financial resources are necessary to carry out the proper functioning of missions. A multilateral national response incorporating MOUs and IGAs characterizes interdependence, and integration is an institutional response realized through consortia, treaties, and conventions.

The range of outcomes demonstrates that responses other than national ones have played roles in the cooperative equation. Institutional responses are evident in the space law regime, Intelsat, ESA, IACG, and CEOS. UNCOPUOS served as a forum for codifying the Outer Space Treaty of 1967 which established an international space law regime; Intelsat exists as an IO on the basis of an operating agreement concluded in 1971; ESA is a multinational byproduct of former European space-based IOs (ESRO and ELDO); IACG was formed on an institutional basis through multilateral agreements among national space agencies and scientists on terms of reference; and CEOS was conceived through agreement on data exchange principles that are supported by a number of IOs.

National and institutional responses can involve epistemic collaboration as well. This is relevant for several cases of cooperation concerning human spaceflight, space sciences, and Earth sciences. In human spaceflight, epistemic groups realized initial working and technology transfer arrangements, which were formalized in a 1972 US-Soviet IGA that led to ASTP. The development of an androgynous docking mechanism for the proper functioning of ASTP involved joint working groups of engineers. Additionally, epistemic communities from national space agencies of the US, Europe, Japan, and Canada coordinated plans for a space station in 1982-1983 even though no respective government had approved the program.

In space sciences, ESA manages its programs through the SPC composed of delegates with competence in scientific matters. The genesis of cooperation in ISPM (Ulysses) emanated from transnational scientific collaboration among epistemic groups interested in exploring and investigating the solar environment of the Sun. For IACG, it was transnational epistemic communities of space scientists (e.g., International Halley Watch) that initiated and sustained coordination to study Halley's Comet. In Earth sciences, transnational epistemic collaboration has been indispensable for realizing mission goals. These goals, as CEOS exemplifies, are directed at sharing of data from Earth observations by satellite for global change research use.

Technological and Scientific Resources

Dynamics pertaining to technological resources involve how those resources are distributed among cooperating partners. Distribution patterns are governed through technology transfer and typically follow a "need to know" logic. Incorporating clean technology interfaces with no participation in critical path or infrastructure components minimizes technology transfer.

Hardware and systems engineering management are the primary types of technology restricted by national space agencies such as NASA.

Even though a cardinal rule of international space cooperation has been to minimize technology transfer, transfers are allowed if they are within the scope of political actor policy preferences or necessary to technical functions. For example, technology transfer can occur either when symbolic preferences come into play, such as with ISS, or when functional concerns dealing with technical interfacing needs tied to enabling capabilities exist as with Intelsat, ESA, and also ISS.

Conversely, scientific resources are generally shared among national space agencies. Science (e.g., space sciences and Earth sciences) is generally thought of and extended as a collective "public good" to maximize research and public use benefit. The sharing of scientific knowledge is most pronounced when science serves as the primary mission goal. This is true for ESA, ISPM (Ulysses), IACG, and CEOS. Cooperation within ESA emanates from its mandatory programs in space science, which involve transnational collaboration among European scientists and ESA member states; ISPM (Ulysses) and IACG put forward mission goals with the intent of maximizing scientific returns; and CEOS advocates principles, such as "maximize use for public benefit," that view the production and dissemination of science (i.e., data about global change processes) as a collective good.

Provisions that assign intellectual property rights to knowledge creation often govern the extent to which science is shared. Rights are put into place to ensure proper licensing of knowledge for application purposes such as patents. This is of concern to national space agencies because knowledge-application involves transforming knowledge-creation into some type of technology with possible commercial or other benefits. Consequently, this may have implications for engineering know-how and technology transfer. The space station program regulates the distribution of scientific resources through intellectual property right provisions established in the ISS IGA of 1998.

Authority and Decision-Making Patterns

Authority patterns depend on whether a case is bilaterally or multilaterally arranged in decision-making and management. Patterns of authority in bilateral arrangements, like MOUs and IGAs between NASA and a foreign partner, suggest that cooperation is a reflection of national policy preferences and national responses. This is true of US-European, US-Japanese, and US-Russian intergovernmental space relations. In contrast, multilateral arrangements, agreements on principles, conventions, or treaties,

display institutional authority patterns. The law regime, Intelsat, ESA, IACG, and CEOS exhibit these characteristics. Intelsat and ESA were formed to develop and manage integrated programs whereupon funds for program implementation are turned over to the respective IO by participating national members; and IACG and CEOS institutionalized principles for sharing science among a number of national and international members.

One unique case is the ISS. The cooperative framework for ISS incorporates both bilateral and multilateral decision-making and managerial arrangements. ISS MOUs specify bilateral arrangements between NASA and the space agencies of Russia, Europe (ESA), Japan, and Canada, and a multilateral IGA exists among the governments of these agencies. Since the 1998 ISS IGA establishes a common policy and legal regime for managing all aspects of the cooperative relationship, it reflects more of an institutional arrangement.

Functional Policy Preferences

Functional policy preferences are a defining feature of US-European and US-Japanese patterns of bilateral cooperation. Cooperation dynamics in ESL, ISPM (Ulysses), and space station in 1988 are all characterized by NASA's functional policy preferences. It is the ability for NASA to impose these preferences on another party, even if those preferences are not compatible or shared, which gives rise to augmentation.

Functional preferences also played a role in the development of institutional responses for cooperation as typified by the law regime, Intelsat, ESA, IACG, and CEOS. Institutional responses were viable because symbolic preferences were either subordinated or coincided with international or transnational ones rooted in functional issues related to sharing of technological and scientific resources. This implies that coordination and integration, which characterize the aforementioned historical cases, are grounded on compatible functional policy preferences.

Symbolic Policy Preferences

Symbolic policy preferences matter when national political actors perceive that international space cooperation offers opportunities to realize domestic and foreign policy agendas. The space law regime, especially concerning freedom of passage in space, was supported because it advanced US and Soviet national security interests in spaceborne reconnaissance;

Intelsat was an integral part of US "space diplomacy" during the 1960s and 1970s; ESA promotes, in addition to European foreign policy interests, industrial policies of European states; and space station is symbolic of US foreign policy interests. As with functional preferences, the extent to which symbolic preferences are compatible plays a role in influencing outcomes. In this regard, coordination, interdependence, and integration emerge when symbolic policy preferences are compatible or shared between cooperating partners.

CONCLUSIONS: THE FUTURE OF SPACE COOPERATION

The future of international space cooperation will be based not only on the policy and functional preferences of states as discussed herein, but also on market factors. Space cooperation is evolving to include significant cooperative commercial space relations.[133] Future research on international space cooperation will undoubtedly have to explicitly consider market factors and globalization processes. These aspects are represented today by the emergence of a multinational and transnational space industry that was discussed in the previous chapters on Space Commerce and Space Business.

Carl Sagan made the case that global cooperation is an essential precondition for the survival of planet Earth.[134] Ironically, what began in deadly competition, Apollo and the space race, has given way to both a political and commercial paradigm of cooperation. Today and in the future, it is hard to imagine that a major governmental or commercial space program could be undertaken without international space cooperation.

15
COMPARATIVE SPACE POLICY: THE SPACE POLICY CRISIS IN THE AMERICAN, EUROPEAN, AND FRENCH SPACE PROGRAMS*

Xavier Pasco†
Laurence Jourdain‡

> For several years, a malaise has been developing on our [European] continent. The budgetary difficulties experienced by our states and the international turbulence have slowed down or even stopped some programs. We have to get rid of that feeling which brings out a deteriorated image of what our country [France] wants. Nowadays, it is time to launch new perspectives for a new start.
>
> *J. D. Levy, Director General, Centre National d'Études Spatiales (CNES)*

INTRODUCTION

Since the end of the 1980s, policy changes within the space programs of the main industrialized countries have engendered a reevaluation of their activities. The collapse of the Soviet bloc and the end of the Cold War have led both the United States (US) and Russia to reduce the extent of their space activities and reformulate their space policies. As a result, other actors, especially the European Space Agency (ESA) and its member states' national programs, have had to revise their priorities in space. In this general context, the global space program is in a "crisis" state on both sides of the Atlantic. Some leading personalities, such as J. D. Levy quoted above- former Director General of the French National Space Agency (Centre National d'Études Spatiales, CNES)– have tried to give a rational explanation to these general difficulties by calling for a rebirth of the space program. In the US as in

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Europe such "crisis" rhetoric has been institutionalized through the mobilization of expert committees, ad-hoc commissions, and consulting firms.[1]

This crisis, however, is based on difficulties encountered in one specific domain of space activity, namely the building of large-scale manned orbital complexes. The crisis is one experienced by a specific community confronted with the increasing division of the space sector it had been created to unify. Identifying and treating this crisis often means making some assumptions that can be questioned. A frequent reference is made to a "golden age" of space policy, as it existed during the beginnings of the space age.[2] The genesis of space policy was brought about by the convergence of an exceptional set of historical circumstances linked to the Cold War and the national interest that are unlikely to repeat. As such, the notion of a crisis indicates a higher degree of normalization and maturity for space policy as it has developed and faced policy changes over time. For example, international competition that has driven economic successes observed in the field of telecommunications, remote sensing, and expendable launch vehicles (ELVs) are most often derived from the exploitation of services, rather than stemming from space exploration activity itself; they are generated largely by autonomous industrial structures and not by public agencies like NASA or ESA.

MYTHICAL GOLDEN AGE

The predominant viewpoint within the main space sector calls for the reemergence of an "ideal" founding model, a "golden age" of space development. This model is based on the historical circumstances of the Cold War and specific national contexts, in place at the time, that allowed for the emergence and the unification of a space sector under the auspices of public agencies within the US and Europe. Notwithstanding this process of unification, the emergence and development, in the industrialized countries, of programs aimed at implementing the economic exploitation of space bear intrinsic contradictions. Since such programs are without precedent, are inextricably tied to and influenced by national budgets, and lack clearly articulated social rationales, space policies are perceived as a factor of disruption in political systems and public policies. Because space policies were conceived in relation to the military sector and nuclear deterrence within a heterogeneous civil-military institutional context, their identity and legitimacy from the start was fluid and fragile. Thus, over time it was natural to expect that a space policy crisis would emerge.

American "Space Model"

The space program, born in the mid-1950s, stemmed from antagonistic confrontation between the US and Soviet Union when the strategic balance was starting to depend on the performance of nuclear ballistic missiles and on the ability to survey the adversary's capabilities. Even before the Soviet launch of Sputnik in 1957, US political authorities were fully aware of the psychological advantage that could be drawn from a "first" in space. It was recognized that "the costly consequences of allowing the Russian initiative to outrun ours [US] through an achievement that will symbolize scientific and technological advancement to people everywhere... the stake of prestige that is involved makes this a race that we cannot afford to lose."[3] In lieu of the Soviet enemy, the conquest of space symbolized a patriotic wake-up "call to the arms." This implied that allied countries and their trust in American strategic superiority had to be preserved through civil space accomplishments.

The answer to the Sputnik challenge necessitated the organization of widespread and disparate energies that were in competition with each other.[4] One of the main characteristics of the emerging space sector resided in its heterogeneity. The priority was to integrate civilian and military actors and to concentrate the bulk of the technical and budgetary resources there. From this standpoint, the decision to develop an ELV to put an American satellite into orbit as quickly as possible was a pioneering event.[5]

This mobilization effort transpired in a context of political and institutional competition between Congress and the Presidency. The 1958 National Aeronautics and Space Act, which led to the creation of NASA, was the output of congressional activity that prevented the consolidation of space activities in the already existing defense related organizations and institutions; the US space policy at the time was to "delink" the military and civilian components of the space program.

NASA's mission, as established by the Space Act, is to advance scientific knowledge and technological development as well as to preserve the role of the US as a leader in space science and space technology.[6] The creation of NASA as an executive agency reinforced the legitimacy of an omnipotent federal state that foreclosed opportunities for local powers and the private sector. Moreover, the main administrative managers took an active part in this evolution by calling for public authorities to increase their control of space programs that envisioned an American approach inspired by the virtues of mobilization and coherence they were observing in the Soviet Union:

> It is important to note that the recent Soviet attainments are the result of a program planned and executed at the national level over a long period of time… [In the United States], we have encouraged the development of entrepreneurs and the proliferation of new enterprises. As a result, key personnel have been thinly spread. The turnover rate in US defense and space industry has had the effect of removing many key scientific and engineering personnel from their jobs before the completion of the projects for which they were employed…it is not suggested that we apply Soviet type restrictions and controls upon the exercise of personal liberty and freedom of choice. It is suggested, however, that our American system can be and must be better utilized in the future than in the past.[7]

Civil space activity was conceived as a means, at the service of American policy, and not as an end in-and-of-itself. US President Kennedy, for example, made this point when he replied to his science adviser's doubts about the rationales of sending a man to the Moon:

> If you had a scientific spectacular on this Earth that would be more useful– say desalting the ocean– or something that is just as dramatic and convincing as space, then we would do it.

The political purposes of space set the framework in which the space sector was organized. From the manned space activity to the competition with the Soviets for scientific and technological firsts, the space sector matured through NASA. The federal effort was to multiply NASA's budget by ten between 1960 and 1966 with 70% of resources devoted to the Apollo manned activity.

The role of the federal state in civil space administration has often shown itself to be in harmony with the dominant political and ideological values present in public policy debates. It is often difficult to see a clear distinction between NASA projects and the "moral" mission that agency leaders espouse. Such an attitude is evident in a letter by former NASA Administrator, James Fletcher, to several members of US President Nixon's Cabinet in 1971:

> Man has worked hard to achieve– and has indeed achieved– the freedom of mobility on land, the freedom of sailing on his oceans, and the freedom of flying in the atmosphere. And now, within the last dozen years, man has discovered that he can also have the

> freedom of space... Man has learned to fly in space, and man will continue to fly in space. This is fact. And given this fact, the United States cannot forego its responsibility– to itself and to the free world– to have a part in manned spaceflight... For the US not to be in space, while others do have men in space, is unthinkable, and a position America cannot accept.[8]

This collective image about the "national interest" and US security issues has largely contributed to give the Presidency an unrivaled position in the NASA budget process. This is best exemplified by the small differences between the presidential budget proposal and the actual yearly NASA budgets appropriated by Congress.[9]

This situation has had rather ambiguous effects for successive NASA Administrators who have constantly tried to reinforce the autonomy of the space sector by keeping the debate on space programs as far as possible from political controversy. In fact, far from increasing the institutional power of NASA, by installing the space program as a "normal" activity of public policy, the political strife between the President and Congress has constantly reduced the margin of maneuverability for NASA. By making the nascent space community– exploratory, scientific, and industrial– solely representative of the national interest, the public policy debate lacked other compelling rationales and justifications. Consequently, NASA has been unable to make the intrinsic worth of space exploration and utilization its fundamental reason to exist and to gain greater institutional autonomy. The political conditions that presided during the creation of NASA coupled the agency with volatile "national security" values that translated into more institutional instability as those values change.

European Way

During the 1960s, the American "space model" represented both an approach to emulate and a threat for Western Europe obsessed by the idea of bridging the technological and economic gaps vis-à-vis the US. In the space domain, no country in Europe had sufficient capabilities, neither independently nor collectively, to embark on a space race. Originally, only France and the United Kingdom (UK) engaged in nuclear weapons and ballistic missile acquisition programs and thus, could find an interest in knowing how to develop and operate an ELV. The notion of independent access to space remained a much more distant goal due to policy choices and

the economic and social problems that beset Europe during their post-World War II reconstruction.

As early as 1960, British authorities abrogated the development of an intermediate range ballistic missile, Blue Streak, opting to equip their military forces with US made ballistic missiles. By default, France became the “leading” country for European space; its political elites tried to propagate their doctrine of “grandeur” (i.e., modernization, technological autonomy, and independence) on the rest of Western Europe.

French policy in the 1960s was oriented by a strategy of “presence” in every high technology field. In space, like in the nuclear, aeronautic, or electronic fields, the important point was to follow the way opened by the US and to fill the existing technological gap.[10] Strong public research organizations were duly established and associated with high profile industrial groups for operating large-scale technological programs. It is within this environment that the French national space program, CNES, was established and tasked with the development of a national launcher program designated the Diamant.

Despite the symbolic values and the military stakes associated with Diamant, space, unlike that in the US, did not justify a political “call to the arms.” This appeased the internal climate in France; nothing was about to make French public debate reproduce the Cold War dramatization observed in the US. In addition, France lacked the technological capabilities in the 1960s to present itself as a spacefaring nation. As in the other domains, the creation of a space sector first had to fulfill the French doctrine of grandeur without jeopardizing national sovereignty:

> To preserve our independence in the economic, scientific, and technical order...we must make sure that most of our activities remain under French administration and control. We also have to sustain our competitiveness at all costs in the high technology sectors, which command the value, the autonomy, and the life of the whole industrial resource... At last, when it is considered well advised to combine, in a selected area, our inventions, our capabilities, and our means with the equivalent ones of another country, we must choose one that is close to us and one that we think will not put us down.[11]

French grandeur, which had dictated the emergence of a French national space program, did not take hold in other Western European countries. The notions of an external threat and the stigmatization associated with the “partner-competitor” nature of relations with the US were viewed differently from one end of the European continent to the other.

> The Belgian attitude towards the American investments is considerably different from the French one. The Belgian believe that, in the twentieth century, it is better to depend on the United States, just as they depended on the United Kingdom in the Nineteenth Century rather than depending on an expansionist France or a revisionist Germany... The Netherlands, Luxembourg, and Italy prefer as well an opened Europe that relies on the United States.[12]

Notwithstanding, Western European governments began to converge on their space policies in the early 1960s. Wishing to revive their military rocket, Blue Streak, British authorities offered it to their European partners as the first stage in the development of a common ELV called Europa. This initiative took shape in 1962 through the creation of the European Launch and Development Organization (ELDO), which was composed of Belgium, France, Germany, Italy, Netherlands, and the UK. From its onset, ELDO was beset with political problems. Since it was devoted to the construction of Europa without any kind of supranational authority, ELDO tended to embody French ambitions of grandeur. This was complicated by the fact that each government maintained complete control of its contributions to Europa. This spawned controversial debates within ELDO about the relevance of a European ELV, while Europa development had to deal with numerous technical failures due to a lack of systems management and integration. In 1968, Germany, Italy, and the UK announced their withdrawal from the organization. Germany, in particular, has for a long time hesitated between indigenous European engagements and its inclination for cooperation with the US.[13]

The evolution of a space sector in Europe has also derived from another image, supported by scientific elites in search of a larger domain of action and influenced by the universalistic and scientific "utopias" of the post World War II years. At the moment when the Europa project was taking shape, several prominent scientific figures promoted the idea of an autonomous multilateral space organization that focused on science and excluded any kind of military or commercial activity. European space had "to get rid of any kind of political hegemony and to admit that national interests are secondary to humanity's well-being."[14]

This led to the creation, in the same year as the formation of ELDO, of a second space organization, the European Space Research Organization (ESRO), by Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland, and the UK.[15] ESRO prerogatives were limited to promoting cooperation between member states in space research and

technology. The development of ESRO was affected by serious institutional and financial crises, albeit this was less problematic than the national-supranational controversies within ELDO. More specifically, it was faced with political obstacles as soon as the issue of extending its prerogatives to the construction of commercial application satellites was raised; ESRO failed to reach a compromise between the states favorable to developing an autonomous European launcher and commercial applications– led by France– and those more oriented toward the scientific nature of space exploration.

Given the initial failures of ELDO and ESRO, a European Space Conference in the early 1970s decided to merge the two organizations into a unique organization named ESA.[16] The Conference also decided to adopt several new programs: the Ariane, related to development of an ELV follow-on due to the failed Europa; a maritime navigation satellite, Marots; and a manned laboratory, Spacelab, which was aimed at European participation in the US Space Shuttle program. European space policy depended on a very specific programmatic context that tried to balance concerns for autonomy through indigenous technological development and cooperation with the US. Since Europe lacked the sustained "national security" ideological values and norms adopted as an identification factor to unify the space community in the US, European space policy has developed in a more piecemeal fashion.

The ESA mission is to "ensure and develop exclusively for peaceful purposes the cooperation between the European States in the field of space research, technology, and applications for their use in scientific research and in operational application space systems," to "conceive and implement an industrial policy appropriated to its programs," and to "coordinate the European space program and the national programs."[17] ESA's policy is defined by a council representing all the member states (with one vote for each state) at the ministerial level. A Director General is in charge of policy implementation. In parallel, several committees have been created: the scientific program committee (SPC), the financial and administrative committee, the industrial policy committee, and the international relations committee.

Aspects of ESA's organizational and institutional dynamics include the following:

> A simple majority makes council decisions, but signatory states have imposed major exceptions– unanimity is necessary for any international settlement, for the admission of a new member state, for the coordination of the national policies, for revising the ESA Convention, and for fixing the five-year budgetary cycles and ceilings; and a two-thirds majority is required in some cases, such as for the adoption of the annual budget or for the nomination of

the Director General.

The signatory states have imposed the so-called "juste retour" rule ("just return" or "geographic return rule")– according to the ESA Convention, the Agency has to make sure that all the member states participate on an equal basis, considering their respective financial contribution to the implementation of the European Space Program and to the development of space technology. The "just return" ratio is the ratio for each member state between its ESA budgetary contribution and the amount of ESA industrial contracts awarded within the member states. This ratio was initially fixed at 0.8 and was raised to 0.96. This rule, which essentially guarantees that certain companies will have a work-share on projects even before the companies have submitted their bids, has recently become a point of controversy among member states in regard to the Galileo project.

ESA's major innovation involved the introduction of mandatory as well as optional programs. The ESA Convention called for both compulsory activities, which every member state shall contribute to, and optional activities, which any member state shall contribute to, except those who formally declare not to do so. Optional programs are coordinated by a specific Director and Program Bureau and follow special decision procedures; no state that sets itself apart from the program has the right to vote on any decision about this program. Moreover, the most important decisions have to be made according to a "double majority" mechanism. This means that starting a new program phase or stopping the program requires a majority of the member states, with the condition that this majority represents at least two-thirds of the contributing members to the program. Ariane, Marots, and Spacelab were the first optional programs of this kind. In order to avoid the prospects of not developing a specific project as a function of this double majority mechanism, Ariane was taken over by France, which assumed more than fifty percent of the costs through direct public subsidies and ownership shares.

ESA has no competence to commercialize space applications or to promote their exploitation– to neither define an appropriate regulatory environment nor negotiate international "rules of the road." In fact, ESA sponsored commercial projects are

> transferred to external organizations with which ESA has a rather low level of coordination. For instance, Arianespace was created in 1980 by several investors to be in charge of the production and the commercialization of the Ariane ELV. France was the principal shareholder with more than 50% of the shares. Another example, Eutelsat (European Telecommunications Satellite Organization), was created in 1982 by national governments and private organizations to develop telecommunication satellite systems. Today, the majority of European states are members of Eutelsat.

For the main actors involved, these new orientations would still be perceived years later as marking the beginnings of a European "golden age." But at the very moment when European space was maturing, a new policy evolution was underway, questioning the model that had finally presided to its development.

BREAKDOWN OF THE MODELS

The embarking of the space race was ephemeral by nature; the main goal to land a man on the Moon was attained by 1969 and the space effort was no longer a policy priority of the US federal government. The 1972 abrogation of the National Aeronautics and Space Council and the rejection of large-scale post-Apollo undertakings, such as a human-tended lunar base and human missions to Mars, marked an end to the golden age of space policy. In this regard, NASA blamed Congress for trying to end the space program in order to finance social programs. This, NASA argued, was a product of misplaced withdrawal and "a dispirited vision of the American destiny in space."[18] The demise of the golden age, brought about by the expression of political hostility towards NASA's post-Apollo programs, competition with social programs, and the privatization of space activities such as in telecommunications and ELVs, marginalized the civil space community.[19]

The European space community saw this demise as an opportunity to be seized and to realize market shares in the emerging telecommunications and ELV commercial industries, while simultaneously appear as credible partners in manned spaceflight. In contrast to the US, the mid-1980s were a period of relative euphoria for European space policy; Europe possessed the institutional tools and technical wherewithal that would allow it to fill the technological and economic gaps vis-à-vis the US. In the space domain, this

dynamic led to the adoption of the ESA long-term plan that called for autonomous European capabilities in human spaceflight.

This euphoric period, however, was short-lived. Given the uncertainties with the NASA-led space station program, Europe's concern with manned spaceflight capabilities began to be contested. Although the French were strong advocates for maintaining this long-term plan, its partners were less supportive; in 1992, Germany announced its decision to freeze its financial participation in ESA human spaceflight programs. These developments brought about uncertainty for the European space program. A French Science Academy report expressed the scientific community's reservations about the goal of having a European in space: "the option of having a man in space does not appear as a priority in the mid-term from a strict technical point of view…this option cannot be justified on the basis of scientific, industrial, or commercial arguments alone, taking into account the announced costs." Given the end of the Cold War and the problems associated with the ongoing economic union of Europe, the founding space policy model outlived its usefulness in European space.

NEW MODEL FOR THE SPACE SECTOR

In the quest for a "new" model for the space sector, different types of solutions have been proposed to deal with the space policy crisis. The main political actors of the space sector agree that adapting to a new political environment is a necessity. This adaptation calls for rationalizing management methods, reforming existing institutional structures, and decreasing costs to enhance organizational efficiency. In the European case, the difficulties related to multinational cooperation have also been denounced; revising the decision-making processes existing in ESA or limiting the effect of the just return principle are among the most frequent proposed solutions. The joint statement made in 1998 by France, Germany, and Italy about reforming European space policy, and the vigorous reaction of ESA personnel to this proposal, is one example of this ongoing debate. In both the US and Europe, analyses and reports about the state of the space program have focused on the need to find clear and compelling objectives and rationales that could engender successful space public policy and thus, programmatic accomplishments.

This space crisis, provoked by the absence of a long-term vision and political will, took on different characteristics in the US than in Europe. In the US, a gap existed between the space and political spheres. The declaration made by former NASA Administrator James Fletcher, before the

US Senate in 1980, was very significant: "in almost every instance, the most severe cuts in the program came from the executive branch and, I am sorry to say, were often politically inspired."[20] For the 1970s and 1980s, the US space community attempted to define itself not solely by the defense of common political interest, but also through the quest of structuring an apolitical "space" identity in opposition to the political sphere.

In comparison, this space-political gap is less clear in Europe given the multinational aspects of ESA. The role within ESA bestowed to a leader country like France is being particularly stressed by golden age values. For instance, the genesis of Ariane is characterized by a high degree of support rooted in technocratic faith on the part of visionary political personalities. However, the hegemony of one member state, such as France, is not sufficient in-and-of-itself to save European space if no process exists to help a common political authority to emerge. For instance, the ESA Council, even in its ministerial form, lacks legitimacy, because it is not competent to make decisions regarding operational follow-on to programs. Whatever the solutions to these problems, the central issue remains to convince political decision-makers and public opinion on the benefits of space activities.[21]

Beyond the technical, structural, and organizational explanations, there is a fundamental questioning about the identity and the meaning of the space effort as a political object. Treating the "crisis" presupposes that the existing cognitive schemes need to be reorganized and reformulated through the promotion of a new policy model for the space sector, one that redefines its place in society.

Utilitarian Doctrine

The declining "exploration" values traditionally associated with the rise of the space age provoked a refocused attention to more practical considerations, through the adoption of what could be called a "space utilitarian" doctrine. At a time when space budgets are stabilizing and even stagnating in real terms, what is at stake is not convincing the public of the exceptional or extraordinary characteristics of space, but rather to make it part of the normal functioning of society and public policy formation. According to the *Advisory Committee on the Future of the US Space Program,* created in 1990 by US President Bush, the ideal space program would be the one that produces, among other things:

> ...effort that yields significant results, so that the American taxpayer can justifiably believe that the organization is accomplishing its

> mission efficiently, effectively and in a fiscally responsible manner, while contributing to our pursuit of knowledge, the quality of life here on Earth, and to inspiration of all peoples.[22]

On this issue, as with others, American and European experiences are rather different. In Europe, the absence of technological heritages, such as Apollo, budgets that are more modest, and a successful experience of coordinating space activities with industrial policies have promoted a utilitarian doctrine. This doctrine has received positive endorsements from key administrative players; the former CNES Director General, J. D. Levy, suggested that “in the future, the field of so-called utilitarian space applications [would] be very large, what is rather obvious for such a sector is that it affects a large number of human activities.”[23] European industrial managers have called for a closer association of space activities and traditional industrial sectors envisioning space commerce as a unifying factor for a new “European” identity.

> Space research enjoys the double privilege to be opened and well suited to the mediums of society. These privileges attract a number of actors from outside the space domain who naturally become synergetic mediums. It is the case for a number of university laboratories or industrial concerns, which find in participation in this activity, a source of commercial value and a tested for their techniques or technologies. But the big industrial groups who devote one of their entities to the space activity are representing the most important medium...by encouraging the internal mobility of people they also create the means to exchange their cultures and skills... space research is also one of the main incentives for the organization and the setting-up of large-scale projects and large-scale international cooperation. By helping Europe develop a widespread technical and scientific culture involving all the countries, the space activity appears at last as one of the pillars of a real European identity.[24]

In the US, such a transformation would imply a much stronger awareness of the societal benefits associated with a space utilitarian doctrine. This can only happen in a rather traumatic way, as it may mean giving up an identity of space exploration and a breaking-up of the civil space community that developed around this identity. During the 1990s, with the increasing role given to military space and with the leadership of former NASA Administrator, Daniel Goldin, that has broken with the traditional image of

the Agency, such a transformation to a more utilitarian doctrine is taking hold. The questioning of the Agency's future implies that NASA is beginning to adapt to the profound policy changes that have affected the American society as a whole, to become an active player in the public policy debate.

> NASA cares about the future of America and all its citizens. Through sharing our discoveries and enthusiasm for making the world a better place, Americans can be rest assured that their future opportunities are boundless and limited only by their own initiative, without regard to their race, sex or economic status... A new NASA is being born– one that will seize the day and provide inspiration, hope and opportunities for all humankind[25]

The US space community has reached the stage where it is taking stock of the consequences of this utilitarian engagement. A normalization of space activities is paralleled by a market-oriented approach and by the development of producer-customer commercial relationships. This approach is sustained by military and governmental support. Large-scale governmental projects remain the core of the US program reflecting an important heritage from past efforts. This is the case even though such projects are considered by many to be strategic errors and incongruous with NASA's "Faster, Better, Cheaper" administrative reorientation at the time. Concomitantly, this reorientation has put forward the goal to control space expenditures and to rethink NASA's role in operational concepts and architectures. This is best exemplified by the reusable launch vehicle (RLV) program and initiatives, which seek full industrial participation for research and development (R&D).

In Europe, commercial successes, represented by Ariane and the French remote sensing satellite system, SPOT, can be taken as examples of publicly managed commercial space programs. But ESA, which remains the only existing relevant structure to organize large-scale programs, falls short of user-oriented commercial needs. Some reforms have been proposed in order to make ESA closer to other European organizations. A case in point is the coordination between ESA and the European Union (EU); in 1998, the European Commission declared that a community action in the space sector was both possible and desirable. This implies that the EU can share its experience and expertise to the service of ESA, create the conditions for an optimal exploitation of space commercial applications through decisions related to the single European market, provide ESA with market outputs through decisions related to agricultural and environment policies, and bring to European space activities political credibility on the international scene that

can be sustained by means of the EU's legitimacy and multilateral social and political foundations.

It is widely accepted that the future of space applications lies in their exploitation for benefit here on Earth. Yet, as seen from the space agency perspective, this logic can appear both dubious and risky. Commercial space activities like those in the telecommunications domain are generally outside the capabilities and interest of government based space sectors. Telecommunications relies on ground services and involves private actors whose corporate interests differ from those of the national space communities. Pushed to its extreme, commercial space activities could lead to an unavoidable dilution of the governmental space sector, which, in turn, could mean the end of a government-based space community as it is defined today. This observation is based on the debates surrounding NASA's future that have forced its management teams to go ahead with restructuring plans. The dilemma is nearly as acute in Europe, both at the ESA-level, whose future plans are the object of a number of reformulations, and for national-based European space programs.

Exploration Ethos

Another type of doctrine that is reemerging is an "exploration ethos"– an ethos that involves justifying space exploration as an intrinsic goal. Inspired by past centuries of geographical exploration, which today carry an important symbolic significance, the concept of an exploration ethos is capable of sustaining the space community. It may represent the only unifying theme able to thwart policy change and the shift from the original model of government space to one of utilitarian space. In 1989, the NASA Office of Exploration remarked how much "the imperative to explore is embedded in our history, our traditions and our national character."[26] NASA representatives advocated that by human exploration beyond Earth orbit and into the Solar System, humankind's aspiration to explore, to discover, to understand, and to apply what we have learned for the betterment of life on Earth and in space could be fulfilled. On the European side, a similar image of space emerged:

> The dream of the conquest of space by man...must be taken into account in the policies we propose...by taking our distances with an immediate utility approach...we are convinced to answer a strong demand addressed to us in favor of the considerable challenge posed by the exploration of space.[27]

In this context, the viability of the space program means to rehabilitate human spaceflight and space exploration.

It is noteworthy that at the time when the European space authorities expressed ambitions plans for human spaceflight, their American counterparts remain particularly prudent and have to carefully balance the scientific and the political rationales underlying such endeavors. The only large-scale human spaceflight project underway, the International Space Station (ISS), has not captured the broad support of the scientific community. In fact, this community has challenged the worthiness and need of the main ISS scientific goal to prepare humans to live and work in space for long-time periods. This situation has reinforced pressures for reallocating money to other scientific programs. For some US congressional representatives, human spaceflight is a symbolic kind of achievement with little utility and commercial pay-offs. Even though the ISS budget has been politically secured in Congress, the past financial difficulties with the Russian contributions as well as the large cost overruns that have developed in the US raise the prospect of future instabilities in human spaceflight and in the exploration ethos as a unifying theme for the civil space community.

The exploration theme, to be legitimate, requires additional rationales. In the US, the quest for exploration must go through the new post-Cold War "paradigm" of international space cooperation.

> If the United States is to maintain its leading position in space, it must invest in diverse mission-oriented space research and development... Leadership in this sense becomes both a goal in itself and the result of excellence in formulating goals for space and achieving them as planned... By taking the lead in shaping future cooperative undertakings so that working together in the civil and the military aspects of space becomes more common and widespread, the United States can enhance its foreign policy, economic, and national security interests as well as advance its programmatic objectives in space... Enhanced international cooperation should be sought not only for its programmatic benefits, but also because it is the preferred way for the United States to influence the direction of future space undertakings around the world.[28]

The idea that the exploration ethos can be sustained through more cooperative international relations falls short in helping its political promotion on the national policy agenda. For example, the diplomatic hesitations that have surrounded US-Russian agreements dealing with cooperation in the human spaceflight area and with the construction of ISS illustrate the breach

that exists between national politics and the exploration ethos. US-Russian cooperation in space was primarily linked to Russian adherence to the Missile Technology Control Regime (MTCR) showing the extent that space affairs have been integrated into American foreign policy. International space cooperation, seen by the space community as a possible economic or political argument in favor of human space exploration, rather reveals itself as a factor tied to changing foreign policy concerns that can promote destabilization for the space sector.[29]

In the end, space community leaders on both sides of the Atlantic are faced today with a similar dilemma: accept and adapt to a normalization process of policy change, which will probably induce the dilution of the public space sector as a specific governmental activity, or try and maintain its political status in an environment of diminishing governmental resources and growing commercial interests in space. This dilemma led to a political change of direction in France where the ministry in charge of space responded to this contrasted vision of space activity by suspending any national political support to human spaceflight activity:

> For long, we have run after this chimera called the Hermes European space shuttle. It was indeed a formidable technical project...but you do not spend billions only to develop aerodynamics. Manned spaceflights are fascinating for some political persons, but the scientists and the industrialists are much more interested by automated flights, which stimulate robotics and telecommunication research...having accepted to participate in this [international space] station was in my view, a technological, scientific, and strategic mistake.[30]

CONCLUSIONS

Space program management and the utility of large-scale civilian space programs are important variables that must be taken into account to give some sense to the evolution of space policy. Space policy decision-makers have long aimed at freeing the space activity, whether commercial or exploratory, from any form of political supervision. The crisis idea itself has appeared as a means to identify a specific space sector helping to keep it united in front of possible dismemberment. This is the paradox that the public space sector faces– to go through a self-destruction process to survive.

Some changes to space public policy have been inspired by this general approach, however, they often reveal governmental management

reform for troubled space issues rather than express the search for more permanent long-term institutional solutions. In the US, the necessity to get out of this situation has been invoked by Presidents, but sometimes with the underlying ambition to put the blame on the "NASA culture" or to regain governmental control over space management and administration. This was the case with the creation of the National Space Council under President Bush (89) and this partially explains the decision to reform the NASA bureaucracy with Faster, Better, Cheaper. In a sense, such measures have allowed the political decision-makers to reject any responsibility for past difficulties and to reinforce the idea of administrative reform as a political panacea. In a similar vein, the suspension of the ESA Hermes space shuttle in 1992 and the loss of an independent European human access to space allowed national European governments to ascribe to the failures of a troubled public space sector.

In any case, the different attempts to give the space sector a new purpose have borne within themselves the seeds of their own demise. The legitimacy of the civil space sector seems to imply some kind of break-up in the communities that defend it. In this respect, the example of the reforms affecting military space programs could provide a conceptual framework for fundamental policy change. The current policy changes in the notions of "national interest" and "national security" involves an integration of military, civilian, technological, and industrial aspects in larger structures such as with the concept of "global information dominance." This appears to have formed a new political consensus, especially in the US, which could help to sustain a significant governmental role in space activities. In fact, telecommunications, remote sensing, navigation satellites, and launcher development, are already, in a de facto fashion, part of this new consensus.

The space crisis in the US and Europe discussed in this chapter indicates that political and institutional actors remain a central player in the public policy debate. At the same time, these actors present adaptation constraints for the space community– either those posited by the renewal of the "national interest" theme in the US or by the interests of national players in relation to ESA. In essence, national governments conform to these interests by creating a specific public policy dynamic and demand. The space policy crisis must be understood less as the result of the coalescing of the space sector and national policies by an omnipotent state and more so as the product of an increasing discrepancy within public policy debates regarding the role of the public space sector. These debates take place within an environment in which political and institutional actors are both the creators of the political problems and the prisoners of the policy outcomes that are more reflective, in the current era, of the utilitarian space doctrine.

16
SPACE AND THE MILITARY

Peter L. Hays*†

INTRODUCTION

Prior to the 11 September 2001 terrorist attacks on the World Trade Center and the Pentagon, a confluence of trends and recent developments had raised national security space issues close to the top of the American defense policy agenda. Throughout the space age, many space activities have been extremely contentious because of their profound implications for global politics and United States (US) national security. During the Cold War, US strategies for using space ran the gamut from plans for nuclear doomsday bases on the Moon,[1] to attempts to preserve space as a sanctuary used for peaceful purposes only.[2] The Gulf War was heralded as “the first space war” and highlighted the many important ways in which space systems enhance the war fighting effectiveness of terrestrial forces.[3]

Today– due to the security challenges of the post-Cold War environment, the absence of competition from military peers, space’s role in enabling the information revolution, and the blurring of lines between traditional space sectors caused by the rapid growth in commercial space activity– military space issues are more complex, multidimensional, and controversial than ever before. This chapter examines how military space activities might best contribute to US national security in the new millennium by categorizing US military space activities in terms of sectors, doctrines, and mission areas, discussing the major military space organizations, and analyzing current and future military space issues.[4]

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†The views expressed in this chapter are those of the author and do not necessarily reflect the official policy or position of the Department of the Air Force, the Department of Defense, or the US Government.

MILITARY SPACE SECTORS

The attributes of spacepower are often described using four sectors of space activity: civil, commercial, military, and intelligence.[5] The January 2001 Space Commission Report (*Report of the Commission to Assess National Security Space Management and Organization),* quoted below, provides a comprehensive overview of the types of activities that are contained in each sector and how they contribute to national security:[6]

> *Civil Space Sector*
>
> The civil space sector is approaching a long-standing goal of a permanent manned presence in space with the deployment of astronauts to the International Space Station (ISS). The US has shouldered the largest share of development and funding for this effort. Because it is an international program, however, its benefits for scientific research, experimentation, and commercial processes will be widely shared. The number of countries able to participate in manned spaceflight has grown substantially. In addition to the US and Russia, 21 other countries have sent astronauts into orbit in US and Russian spacecraft. The People's Republic of China has announced its intention to become the third nation to place human beings in orbit and return them safely to Earth. Other research and experiments in the civil sector have many applications to human activity. For example, civil space missions to understand the effects of the sun on the Earth, and missions to other planets and the space between them, such as those conducted by the Solar Terrestrial Probe missions, will help in the development of more advanced means to predict weather on Earth.
>
> *Commercial Space Sector*
>
> Unlike the earlier space era, in which governments drove activity in space, in this new era certain space applications, such as communications, are being driven by the commercial sector. An international space industry has developed, with revenues exceeding \$80 billion in 2000. Industry forecasts project revenues will more than triple in the next decade. Whereas satellite system manufacturing once defined the market, the growth of the space industry today, and its hallmark in the future, will be space-based services. The space industry is marked by stiff competition among

commercial firms to secure orbital locations for satellites and for the use of radio frequencies, and to exploit a global market for goods and services provided by those satellites. International consortia are pursuing many space enterprises; so, ascertaining the national identity of a firm is increasingly complex.

The calculations of financial investors in the industry and consumer buying habits are dominated by time to market, cost and price, and quantity and quality. It is a volatile market. Nevertheless, as a result of the competition in goods and services, new applications for space-based systems continue to be developed, the use of those products is increasing, and their market value is growing. Space-based technology is revolutionizing major aspects of commercial and social activity and will continue to do so as the capacity and capabilities of satellites increase through emerging technologies. Space enters homes, businesses, schools, hospitals, and government offices through its applications for transportation, health, the environment, telecommunications, education, commerce, agriculture, and energy. Space-based technologies and services permit people to communicate, companies to do business, civic groups to serve the public, and scientists to conduct research. Much like highways and airways, water lines, and electric grids, services supplied from space are already an important part of the US and global infrastructures.

The most telling feature of the new space age is that the commercial revolution in space has eliminated the exclusive control of space once enjoyed by national defense, intelligence, and government agencies. For only a few thousand dollars, a customer today can purchase a photograph of an area on Earth equal in quality to those formerly available only to the superpowers during the Cold War. Commercial providers can complement the photographic images with data that identify the location and type of foliage in an area and provide evidence of recent activity there. They can produce radar-generated maps with terrain elevations, transmit this information around the globe, and combine all of it into formats most useful to the customer. This service is of increasing value to farmers and ranchers, fisherman and miners, city planners, and scientists.

Defense Space Sector

Space-related capabilities help national leaders to implement American foreign policy and, when necessary, to use military power

in ways never before possible. Today, information gathered from and transmitted through space is an integral component of American military strategy and operations. Space-based capabilities enable military forces to be warned of missile attacks, to communicate instantaneously, to obtain near real-time information that can be transmitted rapidly from satellite to attack platform, to navigate to a conflict area while avoiding hostile defenses along the way, and to identify and strike targets from air, land, or sea with precise and devastating effect. This permits US leaders to manage even distant crises with fewer forces because those forces can respond quickly and operate effectively over longer ranges. Because of space capabilities, the US is better able to sustain and extend deterrence to its allies and friends in our highly complex international environment. Space is not simply a place from which information is acquired and transmitted or through which objects pass; it is a medium much the same as air, land, or sea. In the coming period, the US will conduct operations to, from, in, and through space in support of its national interests both on Earth and in space. As with national capabilities in the air, on land, and at sea, the US must have the capabilities to defend its space assets against hostile acts and to negate the hostile use of space against US interests.

Intelligence Space Sector

Intelligence collected from space remains essential to the mission of the Intelligence Community (IC), as it has been since the early 1960s. Then, the need to gain access to a hostile, denied land area, the Soviet Union, drove the development of space-based intelligence collection. The need for access to denied areas persists. In addition, the US IC is required to collect information on a wide variety of subjects in support of US global security policy. The IC and the Department of Defense (DOD) deploy satellites to provide global communications capabilities; verify treaties through "national technical means"; conduct photoreconnaissance; collect mapping, charting, geodetic, scientific, and environmental data; and gather information on natural or man-made disasters. The US also collects signals intelligence and measurement and signature intelligence from space. This intelligence is essential to the formulation of foreign and defense policies, the capacity of the President to manage crises and conflicts, the conduct of military operations, and the development of military capabilities to assure the attainment of US objectives.

MILITARY SPACE MISSION AREAS

Another important typology for describing spacepower was first adopted by the US military in the 1980s and still provides a foundational and consistent framework to categorize the military missions that contribute to spacepower. Under this typology, space support is a very broad category that contains all activities that enable military space mission accomplishment. Space support includes the development and acquisition of all military space hardware and software; the entire infrastructure required to launch, track, and command military space systems; and all the personnel, education, and training systems required to sustain military space activities.

Force enhancement is the primary emphasis of military space forces. This mission refers to all military space activities that help to increase the war fighting effectiveness of terrestrial forces and is sometimes referred to as "space support to the warfighter." Force enhancement is further divided into the following mission areas: geodesy, meteorology, communications, navigation, early warning and attack assessment, and surveillance and reconnaissance. Table 16.1 lists current and near-term space systems most closely associated with each of these six mission areas.

By contrast, there is much less consensus on the types of functions that would be required for space control and force application or on the need for the US military to perform such missions. Space control refers to "the ability to assure access to space, freedom of operations within the space medium, and an ability to deny others the use of space, if required."[7] The use of anti-satellite (ASAT) weapons and directed energy lasers are commonly discussed space control missions, but a wide range of missions– including conventional or unconventional attacks on terrestrial telemetry, tracking, and controlling (TT&C) facilities– would also fall into the space control area.

The final category, force application, is usually defined as the use of military force to, from, or within space where the primary objective is to affect the course of terrestrial conflict directly. Space-based ballistic missile defense (BMD) is often discussed as the most important near-term force application mission. Most military space activities fit into one of these four categories and, of course, most of today's military space activities are in the first two categories: space support and force enhancement.

Table 16.1. Force Enhancement Mission Areas.

Geodesy	Meteorology	Communications	Navigation	Early Warning and Attack Assessment	Surveillance and Reconnaissance
Low-Earth Orbit (LEO)	Polar LEO	Geostationary Orbit (GEO)	Semisynchronous Orbit	GEO and LEO	Polar LEO and GEO
Landsat	Defense Meteorological Support Program (DMSP), National Polar Orbiting Operational Environmental Satellite System (NPOESS)	Defense Satellite Communications System (DSCS) II, DSCS III, Ultra High Frequency Follow-on (UFO), Milstar, Global Broadcast System (GBS), Advanced Extremely High Frequency (AEHF), Wideband Gapfiller Satellite (WGS)	Global Positioning System (GPS)	Defense Support Program (DSP), GPS, Space Based Infra-Red System (SBIRS) High and Low	Keyhole (KH) Series, Signals Intelligence (SIGINT) Satellites, Future Imagery Architecture (FIA), Integrated Overhead SIGINT Architecture (IOSA)

MILITARY SPACE DOCTRINES

The four military space doctrines developed by David Lupton in *On Space Warfare* provide an important and comprehensive way to analyze the strategic rationale behind military space activities. These doctrines are summarized in Table 16.2 and shown in relation to the continuum of space weaponization in Table 16.3.[8] The sanctuary doctrine builds on President Eisenhower's concepts of "open skies" and "space for peaceful purposes" by emphasizing that space systems are ideal for monitoring military activity, providing early warning to reduce the likelihood of surprise attack, and serving as National Technical Means of Verification (NTMV) to enable and enforce strategic arms control. The basic tenet of the sanctuary doctrine is that space surveillance systems make nuclear wars less likely. Sanctuary doctrine is closely linked to deterrence theory and the assumption that no meaningful defense against nuclear attack by ballistic missiles is possible. Also, sanctuary doctrine advocates believe that overflight and remote sensing enhance stability, and that space must be kept a weapons-free zone to protect the critical contributions of space surveillance systems to global security.

Survivability emphasizes broad utility for military space systems, not only at the strategic level emphasized in the sanctuary doctrine, but also at the tactical level of space support to the warfighter that has emerged as the most important force enhancement mission since the end of the Cold War. The survivability doctrine also differs from the sanctuary doctrine because it highlights space system vulnerabilities and questions whether space can be maintained as a sanctuary due to ongoing technological improvements in systems such as ASAT weapons.

The control doctrine is analogous to military thinking about sea or air control, and asserts the need for control of space in order to apply spacepower most effectively. Thus, the control doctrine sees space as similar to other military environments and argues that both commercial activities and military requirements dictate the need for space surveillance as well as offensive and defensive counterspace capabilities.

Finally, the doctrine of high ground argues that space is a dominant theater of military operations and is capable of affecting terrestrial conflict in decisive ways. As a primary example of such capability, the high-ground doctrine points to the potential of space-based BMD to overturn the dominance of offensive strategic nuclear forces. This doctrine is also relevant in the debate over weaponization of space as shown in Table 16.3.

Table 16.2. Attributes of Military Space Doctrines.

Doctrine:	Sanctuary	Survivability	Control	High Ground
Primary Value and Functions of Military Space Forces	-Enhance Strategic Stability -Facilitate Arms Control	-Enhance Strategic Stability -Facilitate Arms Control -Force Enhancement	-Control Space -Significant Force Enhancement	-Control Space -Significant Force Enhancement -Decisive Impact on Terrestrial Conflict -BMD
Space System Characteristics and Employment Strategies	-Limited Numbers -Fragile Systems -Vulnerable Orbits -Optimized for NTMV mission	**-Redundancy** **-Hardening** **-On-Orbit Spares** **-Crosslinks** **-Maneuver** **-Less Vulnerable Orbits** **-Stealth** **-Reconstitution Capability** **-Defense Convoy**		
Conflict Missions of Space Forces	-Limited	-Force Enhancement -Degrade Gracefully	-Control Space -Significant Force Enhancement -Surveillance, Offensive, and Defensive Counterspace	-Control Space -Significant Force Enhancement -Surveillance, Offensive, and Defensive Counterspace -Decisive Space-to-Space and Space-to-Earth Force Application -BMD
Military Organization for Operations and Advocacy	-National Reconnaissance Office (NRO)	-Major Command or Unified Command	-Unified Command or Space Force	-Space Force

Table 16.3. Space Weapons Continuum.
Source: Bruce M. DeBlois, Council on Foreign Relations Study Group, "US Space Posture for the 21[st] Century".
Note: ISR is information, surveillance, and reconnaissance; and MCG is mapping, charting, and geodesy.

Doctrine	Level of space weaponization		Type of Activity
	HIGH	10	Permanently orbiting Space-to-Terrestrial Weapons (Unilateral)
High-Ground		9	Temporary, or "pop-up" Space-to-Terrestrial Weapons (Unilateral)
		8	Space-to- Terrestrial Weapons (Multilateral)
		7	Permanently orbiting Space-to-Space Weapons (Unilateral)
Control		6	Temporary, or "pop-up" Space-to-Space Weapons (Unilateral)
	MODERATE	5	Space-to-Space Weapons (Multilateral)
		4	Terrestrial-to-Space weapons (Unilateral)
Survivability	*LOW*	3	Terrestrial-to-Space weapons (Multilateral)
		2	Space-to-Terrestrial ISR, MCG, Communications
Sanctuary		1	Space-to-Space ISR, MCG, Communications
	NONE	0	Terrestrial-to-Space ISR, MCG, Communications

Weaponization

Militarization

SPACE CONCEPTS IN PRACTICE

Almost all of the space concepts discussed above have been reflected in actual programs that received differing levels of national-level support at various times throughout the space age. The first US space policy was highly secret and emphasized creating a legal regime that would legitimize overflight by spy satellites in order to open up the closed Soviet state and stabilize the superpower relationship. The National Security Council (NSC) laid out this secret but overriding priority for the space intelligence sector in NSC-5520 more than two years prior to the launch of Sputnik.[9] This policy explains why the US was not racing the Soviets into space, how the US used its International Geophysical Year (IGY) scientific satellite program as a "stalking horse" to test the acceptability of overflight, and why the dominant public vision of space during the Cold War emphasized sanctuary doctrine and the civil space sector.[10]

Despite their obvious conflict with the prevalent sanctuary doctrine, the military space sector and the concepts of force application and space control also have been important in practice since the earliest days of the space age. For example, the US conducted the world's first ASAT test (Bold Orion) in 1959, developed plans for a significant manned military presence in space with programs such as the Dynamic Soaring (Dyna-Soar) space plane and the Manned Orbiting Laboratory (MOL) program, began the Strategic Defense Initiative (SDI or "Star Wars") program, and tested a new ASAT system in the 1980s.[11] Most significantly, however, throughout the Cold War and into the post-Cold War era, the concepts of force application and space control have remained highly controversial, and most of the programs designed to develop systems for these applications (space weaponization) have either limped along or been cancelled outright.[12]

Recently, two less controversial but perhaps more important concepts, force enhancement and the growing commercial space sector, have emerged as the most important dimensions of US space policy. Force enhancement has long been an important military mission but seldom captured the military's imagination in the same way as the force application or space control missions. In the post-Cold War era, however, force enhancement or space support to the warfighter is clearly the dominant military space mission. This development follows decades of incremental improvements that have created increasingly capable space systems and the widespread recognition of their significant contributions to the stunning coalition victory in the Gulf War.[13]

Two major problem areas stand in the way of continuing improvements in space support to the warfighter: the technical, bandwidth, and data fusion challenges involved in attempting to send real-time, actionable intelligence information directly to the lowest possible echelon of

forces, especially when many of the legacy systems were optimized for strategic and NTMV missions; and the political, cultural, and organizational challenges associated with making these changes. Finally but perhaps most significantly, just within the past few years commercial space activity has grown to make it an important space sector– this development has implications for the military, intelligence, and civil space sectors.[14]

MILITARY SPACE ORGANIZATIONS

The major organizational stakeholders in military space include DOD, the Navy, the Army, the National Reconnaissance Office (NRO) and the IC, the Air Force, Air Force Space Command (AFSPC), and US Space Command (USSPACECOM).[15] These organizations and their cultures form the bureaucratic environment in which US military space policy is developed and implemented.

Generally speaking, only a few major military space policy inputs have been generated at the DOD level, many of these inputs came early in the space age, and most of them were designed to adjudicate roles and mission disputes between the military services rather than to provide overall guidance. For example, in November 1956 Secretary of Defense Charles E. Wilson issued a memorandum that amplified the Key West Agreement on roles and missions by reiterating the Army's exclusion from developing or employing ballistic missiles with ranges beyond 200 miles. This made it very difficult for Wernher von Braun and his "rocket team" at the Army Ballistic Missile Agency (ABMA) to pursue their dream of developing space launch vehicles.[16]

In September 1959 DOD reinforced Air Force primacy in space when Secretary of Defense Neil H. McElroy ruled against Army and Navy efforts to create a unified (multi-service) space command and formally assigned to the Air Force the responsibility for development, production, and launching of space launch vehicles.[17] DOD further consolidated Air Force control over space and established what remained for many years the current basic structure for military space by making the Air Force responsible for "research, development, test, and engineering" of all DOD's space programs or projects under Directive 5160.32 issued in March 1961.[18] This directive gave the Air Force control over nearly all DOD space programs from inception through launch and TT&C. It is important to emphasize that the DOD civilian decision-makers behind these policies were not trying to expand military space or the Air Force's turf. In fact, just the opposite was true– they were eager to consolidate and streamline DOD space activities to reign in the scope of military space and save money.[19]

DOD's March 1987 space policy statement first officially laid out the four military space missions discussed above, and the Department's space policy was significantly revised and expanded in a 9 July 1999 update.[20] The final piece of DOD-level military space organizational structure was put into place in 1995 when Congress called for the creation of two new offices: the Deputy Undersecretary of Defense for Space and the Space Architect. These offices were intended to provide top-level policy review and a mechanism to integrate systems and capabilities across space sectors. However, the Deputy Undersecretary of Defense for Space part of this new organizational structure was eliminated in the Defense Reform Initiative announced by Secretary of Defense William S. Cohen in November 1997, and the Space Architect's office was also realigned and renamed the National Security Space Architect.[21]

The Navy's military space efforts have centered on missions that are crucial for maritime forces such as surveillance, communication, and navigation, but it is also quick to point out its long tradition of operating exploratory missions on new seas.[22] The Naval Research Laboratory (NRL) developed the Vanguard booster for the IGY program, the Galactic Radiation and Background (GRAB) experiment (the first electronic intelligence satellite), the Transit system (the first space-based navigational aid), and throughout the space age the Navy has emphasized developing improved communication capabilities such as those currently deployed in the Ultra-High Frequency Follow-on (UFO) communications satellite system. In the late 1950s, the Navy led the unsuccessful attempt to create a unified space command and created its own Naval Space Command in 1983.

At the end of World War II, the Army was arguably the organization in the best position to become America's space service. It had captured the lion's share of von Braun's team, along with their blueprints, files, and parts for V-2s.[23] Moreover, the Army believed it was well suited to open the space frontier due to its rich tradition in civil exploration, such as the Lewis and Clark Expedition, and its civil engineering efforts led by the Topographical Engineers and the Corps of Engineers. Of course, America's first satellite did eventually ride into space atop a modified Jupiter missile assembled by von Braun's team and derived from the V-2, but this proved to be the high water mark of the Army's space efforts. Following this achievement, the Army was largely stripped of its space capabilities by a series of DOD decisions to award the military space launch mission to the Air Force, and national policy-level decisions to create NASA and emphasize the civil space mission. The Army's Jet Propulsion Laboratory (JPL) became NASA's first center, and von Braun's team at ABMA became NASA's Marshall Space Flight Center. By the 1980s, the Army had regained some of its enthusiasm for space activities and, following the Navy's lead, created the Army Space Command in 1988.

Like the Navy, the Army prides itself on its ability to effectively use the force enhancement capabilities provided by space systems.

As indicated earlier, throughout most of the space age the sanctuary doctrine and intelligence sector dominated US space policy. The NRO perpetuated this emphasis in US space policy and was in many ways the most powerful military space bureaucracy during the Cold War, even though it was a black organization from its creation until its existence was declassified in 1992.[24] On 25 August 1960, President Eisenhower decided that spy satellites (spysats) required a new national-level organization to channel their strategic intelligence feed directly to top-level decision makers, hide and streamline the process of developing and operating spysats, and because of the concern over military rather than civil control of spysats.[25] As the NRO's technical prowess grew, it became increasingly tied to arms control and NTMV. There was a subtle but important link between the NRO's improving capabilities and the units of limitation in arms control agreements. When the first Strategic Arms Limitation Treaty (SALT I) was signed in 1972, NTMV was responsible for counting large, fixed facilities such as missile silos and phased array radars. By the time of SALT II in 1979, NTMV was expected to track mobile launchers, distinguish between different types of missiles, and even monitor the number of warheads per missile.[26]

Evidence of the NRO's secret but heavy hand in guiding space policy can be seen in the 1969 cancellation of the Manned Orbiting Laboratory (MOL) in favor of unmanned reconnaissance systems, in the way the Space Transportation System (STS or Space Shuttle) cargo bay design specifications evolved to accommodate future generation spysats, and by the fact that prior to the 1986 Challenger disaster the NRO was the only US government organization that was allowed to develop an alternative space launch capability to back-up the STS.[27] The NRO must now adapt to its changed role as an unclassified organization in a post-Cold War environment where collection on a wide and difficult array of intelligence targets currently takes priority over its traditional NTMV function.[28]

The Air Force is the most powerful and important military organization in the military space sector, but its position as the DOD's main space player also presents it with very difficult conceptual and organizational challenges. The Air Force often must walk a difficult tightrope on space issues, and the stakes involved may include its very existence. It must be proactive enough to satisfy those groups both inside and outside the Air Force that believe the military should be doing more to pursue force application and space control, or that it is not working hard enough on force enhancement. At the same time, it cannot be so proactive on space that it alienates the pilots and airpower mission at its institutional core. If the Air Force is not perceived

to be moving quickly enough on space, it may inflame those who believe that only a separate space service can properly advocate for military space. If it moves too quickly, it may undercut its responsibility to develop airpower capabilities in pursuit of a "space chimera." Of course, in an ironic twist, the Air Force's organizational dilemma of how to pursue spacepower is exacerbated by the institutional baggage surrounding its own creation as a separate military service as well as by the continuing doctrinal ferment over the efficacy of airpower.

Given these organizational sensitivities and the sanctuary doctrine mindset of the Cold War, the Air Force's sometimes hesitant and halting approach towards space is not surprising. In the late 1950s, Air Force Chief of Staff General Thomas D. White advocated the "aerospace" concept- a concept that has helped to define the importance of space for the Air Force and the Air Force's role in space ever since.[29] The aerospace concept sees air and space as one indivisible medium and strongly implies that the Air Force is the service best prepared to conduct aerospace military operations to control and project power from this medium.[30] In keeping with the aerospace concept and anticipating approval of significant space control and force application missions, the Air Force pushed hard for manned space systems such as Dyna-Soar and MOL. When these programs were cancelled, the Air Force recognized the full strength of national policy support for the sanctuary doctrine and the civil space sector.[31] For the remainder of the 1960s until the late 1970s, the Air Force was resigned to the sanctuary doctrine and did not give much consideration to expanding military space operations.

Several factors, such as the breakdown of détente, the first STS flights, and SDI, helped to reignite Air Force thinking about military space. When the Air Force established the AFSPC in September 1982, it signaled that space had become a primary operational focus. AFSPC centralized and consolidated a number of functions that had been performed primarily by Air Force Systems Command. Transforming the USAF space community's organizational culture from its roots in Systems Command's research and development (R&D) mindset to the operational focus desired by AFSPC proved to be a long and difficult process. This transformation– and not the innovative space doctrine leadership desired and expected by most of those who had championed the creation of AFSPC– consumed much of AFSPC's time and attention for the remainder of the Cold War.

The establishment of USSPACECOM in September 1985 created DOD's most effective military space advocate, but also added an additional bureaucratic layer that sometimes complicates organizational loyalties and military thinking about space. In terms of bureaucratic politics, the creation of the unified command was the quid-pro-quo demanded from the Air Force by DOD and the other military services as the "price" to pay in order to create

AFSPC.[32] It is also interesting that this outcome was the opposite of the situation in the late 1950s when the Air Force had been successful in blocking the attempts of the other services to create a unified command for space. Finally, it is worth noting that to at least some observers USSPACECOM does not receive the respect from the military services that it deserves as a unified command. It has sometimes been marginalized both by AFSPC, which controls about 90 percent of military space personnel and funding, and by the regionally organized unified commands that have much better defined war fighting roles and areas of responsibility than USSPACECOM.[33]

MILITARY SPACE POLICY ISSUES

There are a number of policy issue areas that fundamentally influenced the development of USSPACECOM's *Long Range Plan* and will shape US military space policy over the next two decades: the rapid expansion of commercial space activities and perceptions of space as an economic center of gravity (COG); space launch and range infrastructure issues; the implications of high-resolution commercial remote sensing; positioning, navigation, timing, and global utilities (Global PNT); the space dimension of missile defense; and the ongoing debates over space's proper role in the revolution in military affairs (RMA), Transformation, information operations (IO), and over the Space Commission and how to organize for military space.

Space as an Economic Center of Gravity

The most important set of factors that currently shape perceptions of military spacepower relate to the growing commercial importance of space and claims that it constitutes an economic COG. Perceptions on the importance of these factors vary considerably, but they nonetheless became a central theme in USSPACECOM's public discourse during the latter half of the 1990s. This emphasis was most pronounced during the tenure of General Howell Estes as Commander-in-Chief of USSPACECOM (CINCSPACE) and continued during the tour of General Richard Myers, but, interestingly, was not repeated by General Ralph Eberhart, the last CINCSPACE[34]. The increased use of the term COG to describe the commercial space sector coincided with rapid actual growth in commercial space activities in this period, but it was predicated even more directly on projections of exponential growth that have not panned out. Forecasts during 1997 and 1998 called for

growth at a "blistering rate of 20 percent a year" to support a "gold rush in space."[35]

> 550 satellites today are in Earth orbit, performing numerous critical defense and civil functions. Nearly half of them belong to the US, and half of those are commercial. US space investment now exceeds $100 billion, and the stakes are about to go higher.
>
> Expectations are that the US and the world's other spacefaring nations, over the next five years, will pump another $500 billion into space. They will launch at least 1,000, and possibly 1,500, new satellites. Most will be commercial systems. Many will have military significance.
>
> "We'll see commercial use of space go out of sight," said USAF's Chief of Staff, Gen. Michael E. Ryan.[36]

General Estes developed and articulated one of the most powerful visions for space of any CINCSPACE to date. Early in his tenure (August 1996 to August 1998) Estes emphasized the emergence of space as an economic COG at virtually every opportunity. In one of his earliest and most sweeping speeches, delivered at the US Space Foundation's annual symposium in April 1997, he introduced several major themes he would reiterate in speeches and in reports during the remainder of his term:

> Today, more than ever, it is important that all Americans understand that our investment in space is rapidly growing and soon will be of such magnitude that it will be considered a vital interest– on par with how we value oil today...
>
> Now while it might seem appropriate that I should be more concerned with military space, I must tell you that it is not the future of military space that is critical to the United States– it is the continued commercial development of space that will provide continued strength critical for our great country in the decades ahead. Military space, while important, will follow.
>
> Commercial space, as I said earlier, will become an economic center of gravity, in my opinion, in the future and as such will be a great source of strength for the United States and other nations in the world. As such, this strength will also become a weakness, a vulnerability.

> And it's here that the US military will play an important role, for we will be expected to protect this new source of economic strength.[37]

Space as an economic COG was also an important theme in the *Long Range Plan,* the most important report USSPACECOM released during General Estes' tenure:

> Space capabilities are becoming absolutely essential for military operations, national commerce, and everyday life. In fact, space is emerging as a military and economic center of gravity for our information-dependent forces, businesses, and society. Life on Earth is becoming inextricably linked to space...
>
> Although the notion of space as a sanctuary appears seductive to many, our increasing reliance on space systems, and information derived from space, creates a center of gravity potential adversaries clearly understand. Protection takes on a new dimension as non-DOD systems (commercial and third-party) become even more integrated into plans for using joint forces.[38]

General Estes linked this vision of a growing commercial space sector directly to the assumption that this growth would prompt calls for an increased military role in protecting "this new source of economic strength." The logic of this "flag follows trade" argument is clear and has historical precedents, but to date it has not yet prompted any significant calls for better protection.[39] If anything, the general attitude of the commercial space industry has thus far minimized threats to their systems and denied the need for better military protection; there is no demand at this point from the operators of commercial communications satellites for defense of their multibillion-dollar assets. Despite the industry's tepid response, the Air Force continued to emphasize the flag follows trade route to a greater military space presence.

General Estes was an influential member of the Air Force's General Officer "Board of Directors" that agreed following a meeting in November 1996 to issue *Global Engagement*– a sweeping new vision statement for the Air Force. This statement corresponded closely with the perception of the importance of space to the nation and asserted that the Air Force is now transitioning from an "air" force into an "air and space" force on an evolutionary path to a "space and air" force.[40] In a related bureaucratic move, General Estes also attempted to have space designated as an "area of

responsibility" (AOR) similar to the AORs assigned to regional commands by the Unified Command Plan (UCP). As a result, CINCSPACE was designated as the single focal point for all military space operations, but the 1998 UCP stopped short of his recommendation to make space a dedicated AOR.[41]

General Myers served as CINCSPACE from July 1998 until February 2000. He generally reiterated General Estes' emphasis on space as an economic COG but added three important changes: first, that space was already a COG; second, that space was a military and economic COG; and third, that US reliance on commercial space created vulnerabilities easily exploited by potential adversaries. One of Meyers' first pronouncements along these lines came at the Air Force Association Space Symposium in November 1998: "space has become a military and economic center of gravity. So much of the world's standard of living, so much of its commercial wealth depends on space."[42] Later in his CINCSPACE tenure, General Myers put more emphasis on how US reliance on commercial space was creating new vulnerabilities: "...our reliance on commercial space has created a new center of gravity that can easily be exploited by our adversaries."[43] Before leaving this tour, General Myers emphasized the importance of space control in an editorial for *Aviation Week & Space Technology*:

> Space is a military and economic center of gravity. We cannot afford to take it for granted. Only through a robust space control and modernization vision can we thwart military or terrorist attacks, and manage the space "gold rush," while continuing to reap tremendous benefit, both in economic and national security terms.[44]

General Eberhart, who assumed the CINCSPACE position in February 2000, usually avoids using the term COG to describe the economic and military importance of space and, in general, has not placed as much emphasis on the growth and importance of the commercial space sector as did Estes and Meyers. Eberhart's approach reflects the recent slowdown in commercial space, the Air Force's renewed emphasis on the aerospace concept and integration as stated in its June 2000 vision statement, *Global Vigilance, Reach & Power,* and the major recommendations in the Space Commission Report.[45] The Air Force's 2000 vision statement moved the Air Force "back to the future" by returning to "aerospace" (the concept originally articulated in the 1950s) and abandoning the separate "air and space" construct that was introduced in June 1992 and emphasized in the November 1996 *Global Engagement* vision.[46] In the latest iteration of this semantic debate, as of November 2001 the Air Force once again adopted the separate "air and space" construct.[47]

General Eberhart has stressed personnel issues such as retention problems; USSPACECOM's efforts to come to grips with its newest missions, computer network defense (CND) and computer network attack (CNA); and the need for space control.[48] Eberhart also recommended the formation of a Space Tactical School to "develop space warfare concepts" and created the "Space Aggressor Squadron, whose job it is to play against the Air Force and other services in war games such as Red Flag and to heighten both military and civilian awareness of the threat..."[49] One of the best illustrations of these subtle changes in emphasis came in General Eberhart's November 2000 interview in *Aviation Week & Space Technology*:

> Integration has been exactly the right thing to concentrate on these last 5-10 years, as we tried to harness the national systems... The fact that we heard so much about [the need for integration] after Desert Storm, and did not after Kosovo, tells me that we are on the right track. Now, we need to make sure we can protect the capabilities that resulted from that integration... I do not think we would be good stewards of space if we only thought about integration. We also need to be spending resources and intellectual capital on space control and space superiority... The importance of space control and space superiority will continue to grow as our economy become more reliant on space... If we only look at space in terms of integration, in my view, we will fall into the same trap we fell into with the airplane... We [initially] thought of it in terms of intelligence, surveillance, reconnaissance, communication, and weather [support]. If we only think of space in these ways...a "higher hill" as opposed to a center-of-gravity. We have to be able to survey, protect, and negate under this space control mission.[50]

But is commercial space truly an economic COG for the US? More than most, commercial space is a volatile industry that been through several boom and bust cycles and has often delivered less than promised. It is also highly complex because it is closely tied not only to economic cycles, but also to many other factors such as technological developments, international politics, and domestic regulation. USSPACECOM's assertions during 1997-99 that space is an economic COG were made based on projections drawn from the commercial space sector's strongest ever growth cycle. The "gold rush" mentality of firms seeking competitive niches in the communications spectrum or in specific markets reinforced perceptions that commercial space would remain in a cycle of continuing upward acceleration. The resulting

projections too often relied on best-case scenarios, rather than more somber economic analysis, and they also suffered from the lack of an objective and timely overall market survey.

Analysts currently have far better insight into these issues due to the slower actual development of the markets over time. The Futron Corporation's new annual *Satellite Industry Guide* helps to address the latter problem.[51] Using this more recent and accurate data one overall conclusion immediately jumps out that as of 2002 commercial space activity simply has not developed in the directions and magnitude projected as recently as three to four years ago. Despite the significant growth of the commercial space sector in the second half of the 1990s, the trajectory of actual developments is falling significantly short of the projected vector (e.g., $500 billion investment and 1000 plus launches by 2003) that had been touted in forecasts as late as the end of 1998. Commercial space is simply not yet an economic COG for the US in terms of overall value, revenues, or market capitalization.[52]

The cumulative contributions of all space sectors undoubtedly make space a strategic COG for the United States. Space clearly has the potential to emerge as an economic COG for the United States and the world in the future.[53] For the next few years, analysts should examine carefully the actual versus projected path of space commercialization and stop inappropriately characterizing commercial space as an already established economic COG. Instead, they should focus on the many implications of a related basic trend that may be more significant and enduring: beginning in the late 1990s, for the first time, commercial space activities and investment approached or actually exceeded government activity in areas such as number of launches, and satellite manufacturing and launch revenues. With government space expenditures projected to remain relatively constant, even modest growth in commercial space activities will widen this gap and continue the transformation of the commercial space sector from the smallest space sector into the largest.

The government must consider carefully how its civil, intelligence, and military sectors can best interact with these emerging and dynamic space commercial markets. In many cases, the military sector may be the most appropriate tool to help structure the overall market. This sector must study innovative approaches, such as the civil reserve air fleet model, anchor tenant for new systems as potential methods to leverage commercial systems, or to guarantee itself continuous service at lower rates. The military can potentially save billions of dollars in operations and development costs because it can meet many military requirements simply by purchasing high-quality commercial launch services, remote sensing data, and communications services. Concomitantly, challenges may arise if the military has to compete

for services in a tight commercial market or is forced to use commercial services that do not fully meet military requirements.

Space Launch and Range Infrastructure

Today and for the foreseeable future, there will be considerable pressures on space launchers and ranges due to a combination of factors including the rapid expansion of worldwide commercial space activity, free trade and technology transfer issues, and the requirements for International Space Station (ISS) assembly.[54] Launch is undoubtedly the most competitive component of commercial space due to a wide variety of launch vehicle suppliers, many of which are state-sponsored or otherwise state-subsidized.

The Clinton Administration's August 1994 US Space Transportation Policy formally divided effort on new launch vehicles between NASA and DOD, with the former responsible for developing reusable launch vehicles (RLVs) and the latter responsible for expendable launch vehicles (ELVs).[55] The X-33 and X-34 RLV concepts, and the evolved expendable launch vehicle (EELV) are the programs that flowed directly out of this policy.[56] Under the Space Launch Initiative (SLI) announced by the Bush Administration in March 2001, funding for the X-33 and X-34 programs was ended before any test flights were completed and DOD has not stepped in to fund the X-33 program.[57] In the US there also are several commercial RLV companies in the conceptual development phase, but it is very unlikely that there will be enough demand to keep all of these efforts alive.[58] Other significant factors shaping the near-term prospects of the commercial launch industry include: the continuing recent string of failures in launch or in achieving the correct orbit; the expiration of launch quotas for Ukrainian and Russian launch vehicles; investments by launch providers in non-geostationary systems; launch range standardization and modernization plans; and the successful emergence of Sea Launch– the first commercial sea-mobile launch platform.

According to the Air Force's *Commercial Space Opportunities Study* (CSOS), commercial launch services hold the potential to create the largest cost savings for DOD in both percentage and absolute terms of any commercial space area.[59] The military is projected to spend $1.5 billion on launch services during the next six years in the future years defense program (FYDP) and stands to save some $62-125 million (or 25-50 percent) in annual launch costs once the EELV comes on line.[60] If the EELV program is successful in significantly reducing costs per kilogram to orbit, it will represent a major breakthrough since, despite years of repeated promises from

other new launchers such as the Space Shuttle, launch costs have remained constant or actually risen since the opening of the space age.[61]

The EELV program is a novel partnering arrangement between the Air Force and two prime contractors (Boeing and Lockheed-Martin) to build the Delta IV and Atlas 5 as two separate families of medium-lift and heavy-lift vehicles. Instead of following the normal process of selecting a single prime contractor, in October 1998 the Air Force awarded $500 million each to Boeing and Lockheed-Martin and each of these companies are contributing more than $1 billion of their own funds to develop these systems.[62] The EELV and other commercial launch systems lower costs through a combination of factors including reduced launch staffs, less time-on-pad, standardization of launch vehicles, and bulk launcher purchases. Another process to reduce costs further that was identified by the CSOS is "buy-on-orbit" procurement, a method of transferring total system performance responsibility to the contractor that requires less government oversight.[63]

The CSOS touts the EELV program as an outstanding example of how the military can successfully leverage the commercial sector; its primary recommendation is to stay the course on EELV.[64] Potential military risks in this area stem from factors such as competition with the private sector for launchers and pads, having fewer vehicles optimized for military payloads, and unclear future options for both military and commercial RLVs. Perhaps the most potentially significant long-term military risks are associated with RLVs and arise from several factors: NASA rather than DOD still has the lead for developing new RLVs; it is unclear whether NASA will have the necessary funding or motivation to produce any operational commercial or military vehicles; RLVs would seem to be better suited for many projected military missions than for most commercial or civil uses; and the commercial development of RLVs could undercut the commercial development of EELVs.

Launch ranges are a good example of an area where the CSOS could not find a big "pot of gold" for the military due to increased commercial activity. The Air Force currently spends about $600-700 million annually to operate and maintain the nation's primary launch facilities: the Eastern and Western Ranges at Cape Canaveral Air Station and Vandenberg Air Force Base, respectively. The Air Force's Range Standardization and Automation (RSA) program is a $1.2 billion comprehensive effort scheduled for completion in 2006 that is designed to eliminate obsolete equipment, standardize equipment within and between the two ranges, and reduce the number of personnel required for operations (two-thirds of the operators today are contractors rather than military or civil service personnel).[65] Once the RSA is completed, the Air Force looks forward to annual savings of $30-60 million (approximately 5-8 percent of annual operation costs).

The CSOS recommends pressing ahead with the RSA but what is perhaps most interesting is how little support the report gives to proposals to commercialize range activities. This runs counter to the general trend toward increased commercialization in most industrial sectors worldwide, the fact that commercial launches have already edged ahead of government launches, and NASA's apparent success to date in privatizing Shuttle operations and maintenance through the United Space Alliance (USA). Bucking these trends, the CSOS recommends that the Air Force "retain responsibility for flight safety, launch decision authority, and range scheduling..." and ensure independence from private interests.[66]

High-Resolution Commercial Remote Sensing

Operational high-resolution commercial remote sensing providers have ended the virtual monopoly the superpowers enjoyed in this area during the Cold War. This development holds the potential to transform global security in fundamental and pervasive ways, just as spysats changed the global security equation during the Cold War by enabling arms control, serving as NTMV, and stabilizing the superpower relationship. But unlike the benign and stabilizing function normally ascribed to spysats during the Cold War, commercially available and widely used high-resolution remote sensing data may create security implications that are more complex and potentially destabilizing. High-resolution commercial remote sensing may be a global Confidence and Security Building Measure (CSBM) that provides greater transparency to a wider audience of state and non-state actors and makes it increasingly difficult for states to circumvent arms control or hide military operations. Greater transparency, however, may also prove to be a two-edged sword that greatly favors the offense and preemption using long-range precision strike forces.

Under the Land Remote Sensing Policy Act of 1992 and Presidential Decision Directive (PDD)-23 of March 1994, it is now the policy of the US to create incentives to develop a high-resolution commercial remote sensing industry. By attempting to dominate this market, the US hopes to preserve its defense industrial base and workers trained in this sector, leverage commercial systems for government uses, and shape global standards on acceptable use via mechanisms such as shutter control.[67] The primary goal of PDD-23 is "to support and enhance US industrial competitiveness in the field of remote sensing space capabilities, while at the same time protecting US national security and foreign policy interests."[68] Thus, PDD-23 encourages the sale of high-resolution data services from US providers and even includes

provisions for sale of turnkey systems and sensitive components subject to significant export controls and requirements for government-to-government agreements. PDD-23 also imposes several licensee requirements on the sale of high-resolution data including shutter control– the right of the US government to limit data collection and distribution if it determines that national security, international obligations, or foreign policy may be compromised.

The potential for widespread high resolution commercial remote sensing provides a clear illustration of how the growth of the commercial space sector is blurring the distinctions between the space sectors and making security issues more complex. Two US firms, Space Imaging and DigitalGlobe, have operating high-resolution commercial remote sensing systems (Ikonos and QuickBird respectively) and they face significant foreign competition from systems such as SPOT, the Indian Remote Sensing (IRS) satellites (marketed by Space Imaging), and EROS (an Israeli led venture).[69] According to the CSOS, the Air Force spends $10 million annually on commercial imagery; the report recommends that spending be increased to $80 million annually for each year in the FYDP.[70] In this changed environment, the US military must not only learn how best to leverage commercial high-resolution imagery, but also prepare to operate under unprecedented levels of surveillance data that will be highly precise and widely available.

Two recently released congressionally mandated studies reemphasize just how complex and difficult remote sensing issues have become for the US government. Many of the findings and recommendations from the commissions studying the NRO and National Imagery and Mapping Agency (NIMA) go well beyond those in the CSOS by placing a great deal of emphasis on commercial imagery and the IC tasking, processing, exploitation, and dissemination (TPED) process. According to the NRO Commission report, for example, the US government: "could satisfy a substantial portion of its national security-related imagery requirements by purchasing services" from US firms; develop a "clear national strategy that takes full advantage of the capabilities of the US commercial satellite imagery industry;" and create a system to help efficiently focus government systems "on targets where their unique capabilities in resolution and revisit times are important, while commercial systems would be used to provide processed commodity images."[71]

The NIMA Commission report goes even further. It found the IC to be "collection centric," that NIMA was not a good, dependable business partner, and recommended creating a "central commercial imagery fund" to help mitigate problems resulting from the fact that "national technical means (NTM) imagery appears to be free to government agencies, while use of

commercial imagery generally requires a large expenditure of (unplanned, unprogrammed) O&M [operation and maintenance] funds."[72] The commission recommended that the central commercial imagery fund start at about $350 million annually for "raw imagery and vendor's value-added offerings."[73] They expect that this figure will rise substantially throughout the FYDP, and were very "distressed by an announcement promising $1 billion for commercial imagery purchase, which subsequently proved to be so much fiction."[74] The NIMA Commission saved its harshest critique for NIMA's TPED shortcomings. These shortcomings "increasingly strain at the fabric of the NIMA organization as a whole" and undermine confidence "that NIMA currently has the system engineering experience, acquisition experience, appropriate business practices, and performance measures" to acquire a cutting-edge TPED system.[75] The commission concludes that NIMA's TPED efforts simply cannot "get there from here" and recommends:

> ...creation of an Extraordinary Program Office (EPO) armed with special authorities of the Director of Central Intelligence and the Secretary of Defense, augmented by Congress, and staffed beyond ceiling and above "cap" through a heroic partnership between industry, NIMA, and the NRO. The EPO, to be constituted within NIMA from the best national talent, shall be charged with and resourced for all pre-acquisition, systems engineering, and acquisition of imagery TPED– from end to end, from "national" to "tactical." The first milestone shall be completion of a comprehensive, understandable, modern-day "architecture" for imagery TPED. Other provisions of law notwithstanding, Congress shall empower the Director of the EPO to commingle any and all funds duly authorized and appropriated for the purpose of the "TPED enterprise," as jointly defined by the Secretary of Defense and the Director of Central Intelligence.[76]

Positioning, Navigation, Timing, and Global Utilities

Global PNT is another important area where commercial growth is blurring lines and making security issues more complex. The mainstay of Global PNT is the Global Positioning System (GPS). This system was originally designed for military use but rapidly evolved to become important to the commercial sector. GPS applications have quickly multiplied to the point where the system is now often described as a global utility, and GPS applications are almost certain to continue their rapid growth in the

commercial sector for the foreseeable future. Global utilities have been defined as: "civil, military, or commercial systems– some or all of which are based in space– that provide communication, environmental, position, image, location, timing, other vital technical services, and data to global users."[77]

There are also a number of fundamental tensions associated with GPS including: various technical ways to jam the system or overcome selective availability (SA) such as by broadcasting differential corrections; liability issues; what organizations should be responsible for operating the system and how that should be funded; how precise the positioning data should be and what users should be authorized access to the most precise signals; US government policy on the need for and prospects of competing systems such as the Russian GLONASS and the planned European Galileo; and what further standards, such as air and space traffic control, protocols for authenticating and positioning internet users, and interactive positioning and surveillance systems, can and should be built from this global utility.

To date, all space-based global utilities provide information services but they are analogous to Earth-bound utility services that provide a foundation for modern life such as water and electricity. GPS timing signals, for example, are used to synchronize the compressed digitized packages of data within communications networks that use protocols such as Code Division Multiple Access (CDMA) and Time Division Multiple Access (TDMA). Two relatively minor recent failures illustrate just how embedded global utilities have become in the global information infrastructure. In 1996, a controller at the Air Force GPS control center accidentally put the wrong time into just one of the 24 satellites and this erroneous signal was broadcast for just six seconds before automatic systems turned the signal off. That momentary error caused more than 100 of the 800 cellular telephone networks on the US East Coast to shut down and some took hours or even days to recover.[78] In May 1998, "40-45 million pager subscribers lost service; some ATM and credit card machines could not process transactions; news bureaus could not transmit information; and many areas lost television service– all because of the loss of one satellite."[79]

Clearly, space systems have become an increasingly important part of the global information infrastructure, but questions remain about how they should be regulated and protected. There are a number of questions concerning the types of threats these systems face and how these might best be mitigated. Some analysts, primarily in the US military, believe that threats to these systems call for increased space control efforts in order to provide protection.[80] Other analysts note that commercial satellite operators are not clamoring for military protection, wonder if similar threats warrant the development of military space control capabilities, and question whether the

development of such capabilities would, in fact, protect space-based global utilities.

Although perhaps not quite as complex as remote sensing, the current de facto role of the GPS as the global utility for PNT presents difficult policy challenges in balancing military and commercial interests. Moreover, because commercial PNT applications are already large (more than $8 billion annually)[81] and are expanding rapidly and in many different areas worldwide, it is difficult to assess how the military might best leverage the commercial PNT sector. The current GPS constellation consists of 29 Block II, IIA, and IIR satellites launched between June 1989 and January 2001; the system costs over $280 million annually to operate and DOD estimates the total system cost between 1974 and 2016 to be $18.4 billion.[82]

The National Science and Technology Council (NSTC)-6, "US Global Positioning System Policy," formalized the US policy framework for PNT issues in March 1996. To manage the system, NSTC-6 established the Interagency GPS Executive Board (IGEB) that is chaired jointly by DOD and the Department of Transportation. The policy also reemphasized that the US government will continue to operate the GPS "on a continuous, worldwide basis, free of direct user fees;" established the intention to discontinue the use of SA by 2006 (SA was turned off in May 2000); and directed the DOD to "continue to acquire, operate, and maintain the basic GPS," while develop "measures to prevent hostile use of GPS and its augmentations to ensure that the United States retains a military advantage without unduly disrupting or degrading civilian uses."[83]

The US government is attempting to reassess and rebalance various equities as the GPS is modernized to provide significant improvements in its civil, commercial, and military capabilities. In May 2000, President Clinton put more emphasis on the system's growing civil and commercial uses than on its military roots and applications when he described the discontinuation of SA as "the latest measure in an ongoing effort to make GPS more responsive to civil and commercial users worldwide... This increase in accuracy will allow new GPS applications to emerge and continue to enhance the lives of people around the world."[84] Turning off SA has already produced an order of magnitude improvement in accuracy for civil and commercial users; when combined with the two new civil signals (L2 and L5) that are scheduled to first come on line beginning in 2003 and 2005, these sectors clearly seem poised for further accelerating growth. The L2 Coarse/Acquisition (C/A) code is designed for general use in non-safety critical applications and will help to improve "standalone accuracy as low as 8.5 meters (95 percent) compared with approximately 22.5 meters (95 percent) with L1 alone."[85] The second new civil code, L5, is a "safety-of-life" signal designed primarily for

aircraft navigation, but "it will also serve as a robust third signal for all users."[86]

Naturally, DOD's perspective on GPS modernization emphasizes the military utility of the system. The US military is already critically dependent on GPS for a wide variety of applications and this dependence will only grow over time. For example, US precision-guided munitions (PGMs) use GPS guidance for at least some phase of their flight from weapons release to impact.[87] According to March 2000 testimony of Keith Hall, Assistant Secretary of the Air Force for Space, and Director of the NRO: "While sustainment of the constellation is a top priority, navigation warfare (Navwar) requirements and inherent system vulnerabilities have driven the need to modernize."[88] Current plans call for DOD to invest more than $2.7 billion through fiscal year 2005 to operate, maintain, and upgrade the system.[89] In addition to the two new civil signals described above, the modernized system will also have new military codes (M-code) "that will 'reuse' portions of the radio spectrum already assigned to the L1 and L2 frequencies while remaining spectrally distinguishable from the L1 and L2 C/A-codes."[90] It is unclear, however, whether this reuse approach will be flexible and robust enough to enable the US military to use GPS effectively even when the enemy is attempting to jam the system.[91]

Space and Missile Defense

As discussed in the "high ground" space doctrine section earlier, space-based ballistic missile defenses are often considered the ultimate way in which space systems could influence military operations. Of course, at least until President Reagan's 23 March 1983 "Star Wars" speech, such high ground thinking was very controversial not only because it violated the prevalent sanctuary doctrine but also because it contradicted the strategic condition of Mutual Assured Destruction (MAD) and its codification in the 1972 Anti-Ballistic Missile (ABM) Treaty.[92] In the changed security environment of the post-Cold War world, the US is moving past MAD and the ABM treaty as the basis for strategic stability. Nevertheless, the staying power of these Cold War strategic arrangements has been at least as important as any technological challenge in slowing movement toward missile defenses. Despite an intense focus on strategic defense and the expenditure of over $58 billion on R&D, the US still does not have any (space- or other-based) deployed strategic defense systems or even the near-term prospect for deploying any comprehensive system.[93] Throughout, the implications of space-based ballistic missile defenses have remained the most politically charged issues related to military space.

Four recent major developments are most important in shaping the environment in which near-term policy decisions on space-based defenses will be made. The first two developments moved the US away from deploying BMD while the third and fourth have moved deployment closer. Early in his first term, President Clinton reflected traditional Democratic Party ambivalence toward strategic defenses by transforming the Strategic Defense Initiative Organization (SDIO) into the Ballistic Missile Defense Organization (BMDO). As a result, the direction of many strategic defense programs changed. Most importantly, BMDO moved away from the priorities of SDIO and placed its major focus on developing theater missile defenses (TMD) rather than national missile defenses (NMD). In concert with this reordering of priorities, BMDO ended SDIO programs to develop and deploy the Brilliant Pebbles (BP) space-based kinetic kill vehicles as the mainstay of the Global Protection Against Limited Strikes (GPALS) architecture, de-emphasized sea-based systems built around Aegis cruisers and destroyers, and abandoned efforts to share early warning data and manage a cooperative transition to defense deployments with the Russians.[94] Overall, these changed priorities moved BMDO almost exclusively into developing land-based, kinetic-kill terminal defense systems– an area that may be the most politically acceptable, but is arguably the least effective and most technologically challenging for defense systems.

The Clinton Administration also changed the political and legal context for defensive systems in several ways as it was reorienting the technical focus of the program. First, following the breakup of the Soviet Union, it used the Standing Consultative Commission (SCC) to negotiate a multilateralization of the ABM Treaty to include Russia, Ukraine, Belarus, and Kazakhstan as states parties to the treaty. Second, as announced at the March 1997 Helsinki Summit, the Clinton Administration negotiated a demarcation agreement that was intended to maintain the ABM Treaty regime by drawing a line between TMD and NMD. Operationally, the demarcation agreement meant that defensive systems with velocities of less than three kilometers per second (3 km/s) were deemed compliant with the treaty so long as they were tested only against targets with velocities of less than 5 km/s and ranges under 3500 km.[95] Finally, the Helsinki agreement also banned all types of space-based TMD. This prohibition was somewhat overshadowed by the implications of the demarcation agreement but was potentially far more significant.

> Although Article V of the ABM Treaty bans space based ABM systems, space based TMD interceptor missiles are not restricted, except insofar as Article VI (a) precluded giving them “capabilities to

> counter strategic ballistic missiles." And, since Article VI (a) applies only to non-ABM missiles, launchers, and radars (not non-ABM "systems" as is commonly believed), there is no prohibition on space-based lasers for TMD in the ABM Treaty. Thus, Helsinki represents an unquestionable expansion of the ABM Treaty into the sphere of TMD... The Helsinki agreement expands the treaty by foreclosing permanently one of the most promising ways to conduct missile defense – from space.[96]

Further complicating matters, the Clinton Administration never submitted its multilateralization and demarcation agreements for the Senate's advice and consent to ratification.[97]

The third major set of arms control developments that shaped the environment for missile defense came at the end of the Clinton Administration and include: the June 1999 Cologne Joint Statement by Presidents Clinton and Boris Yeltsin that the US and Russia would negotiate on modifications or amendments to the ABM Treaty that would allow the US to deploy a more robust NMD system; the congressional declaration that it is the policy of the US to deploy an NMD system "as soon as technologically possible;" and the reorientation of the Clinton Administration's so-called "3+3" program for NMD. The 3+3 program originally called for accelerated research and testing so that, if warranted by the threat and technological progress, a decision to deploy NMD could be made in June 2000 and the system deployed by 2003. Like almost everything associated with missile defense, the 3+3 program became highly politicized. Supporters of NMD criticized it for not being a development effort commensurate with the threat because it lacked a specific commitment to deploy NMD; critics of NMD argued that the technology to support deployment was immature and opposed this approach because it undermined the ABM Treaty and START II.[98] In this context, Secretary of Defense Cohen's January 1999 statements were quite significant because they indicated a higher level of support for NMD and were a clear evolution away from previous Clinton Administration NMD policy. Specifically, Secretary Cohen announced that DOD would budget funds necessary to pay for an NMD deployment by increasing its future years budget by $6.6 billion; affirmed that there was a growing threat not only to troops overseas but also to Americans at home; indicated that deployment might require modification of the ABM Treaty; and slid the deployment date from 2003 to 2005.[99] Cumulatively, the BMD developments at the end of the Clinton Administration mark a clear retreat from some of the changes associated with BMDO and the Helsinki agreement, and moved the focus of US missile defense efforts closer to its orientation prior to 1993.

Fourth, the Bush Administration (01) has moved rapidly away from the ABM Treaty regime and toward near-term BMD deployments. During the course of three meetings with Russian President Vladimir Putin in 2001, President Bush has made it clear that the US would move forward with defenses, preferably in cooperation with the Russians and within the confines of modifications to the ABM Treaty. Administration officials also emphasized, however, that they were committed to deploying defenses even if that meant the US must do so unilaterally and withdraw from the ABM Treaty.[100] Bush also faced considerable domestic opposition to his plans for accelerating defense deployments and moving away from the ABM Treaty, particularly from leading Democrats in the Senate such as Tom Daschle (D-SD) and Carl Levin (D-MI).

On 13 December 2001, the Bush Administration provided formal notification of the US withdrawal from the ABM Treaty. In accordance with Article XV of the Treaty, the effective date of withdrawal was six months from this formal notification.[101] In addition, Secretary of Defense Donald H. Rumsfeld on 4 January 2002 "approved a major restructuring of the Ballistic Missile Defense Organization that includes a name change [to the Missile Defense Agency] and creates a leaner process for developing and fielding the Defense Department's missile defense programs."[102] Following the 11 September 2001 terrorist attacks and the creation of an international coalition against terrorism, it is unclear how domestic and international support for BMD may change and exactly what types of BMD deployments the Bush Administration intends to advocate or will successfully implement. It is likely, however, that they will find more international and domestic opposition the further they press beyond limited, ground-based deployments and, as in the past, plans for space-based BMD are likely to evoke the most opposition of all.

Revolution in Military Affairs, Transformation, and Information Operations

The final issue areas that are critically important in shaping the environment in which US spacepower will be developed are quite broad and amorphous. They concern the interrelated issues of what role military space activities play in the evolving concepts of RMA, Transformation, and IO, and how the military should best organize for these roles. These issues were particularly important for the two organizations, USSPACECOM and the Air Force, that have the primary role in defining how RMA, Transformation, and IO will relate to military space.

The concepts associated with RMA, Transformation, and IO are far from being fully defined and quite controversial. Two things, however, are clear: RMA, Transformation, and IO have been buzzwords in the DOD for the past decade, and space systems are a critical component in creating these capabilities. To many analysts, the Gulf War presented the first vision of a space-enabled operational integrated reconnaissance complex capable of tailoring military strikes for precise effects in unprecedented ways.[103] To be sure, there were many glitches in the coalition's attempts to achieve this vision during the Gulf War, and there are continuing debates over just how effective the coalition, and airpower in particular, were during the war.[104] Nonetheless, RMA and Transformation advocates believe that the US military can and should build on its Gulf War experience to create a "system of systems" of information age concepts and technologies that will radically improve its combat and war fighting effectiveness.[105]

IO is a cutting edge subset of the RMA that generally refers to military use of computer hardware and software to defend friendly information systems, attack enemy information systems, and exploit information flows.[106] And just as with the RMA, it is often space systems that enable global IO. Some strategists think about spacepower very broadly, arguing "that what has traditionally been perceived as spacepower, is in fact only the beginning of how we will use space strategically" and they also challenge "contemporary thinking on what many have regarded the present RMA to be– namely, it is proposed that spacepower will be the RMA. In order for spacepower to reach its full potential, however, space must be recognized as a geographical environment for conflict that is, in a strategic sense, no different from the land, sea, air, and the electromagnetic spectrum."[107]

RMA, Transformation, and IO can be seen as litmus tests for USSPACECOM and Strategic Command as they struggle to define what these concepts mean for military space and interpret their roles in implementation. As CINCSPACE, General Myers attempted to move USSPACECOM to assume responsibility for IO– an approach that his predecessor General Estes considered but rejected.[108] More recently, USSPACECOM emphasized the command's newest missions, CND and CNA, as well as the growing need for space control and even possibly weaponization of space. As the DOD grapples with how to organize for RMA, Transformation, and IO, USSPACECOM and Strategic Command will face major and open-ended organizational and mission changes that hold the potential to significantly alter their current roles.

For the Air Force, these issue areas present organizational challenges that are even more fundamental and difficult to resolve. Questions concerning how space, RMA, Transformation, and IO fit into the Air Force's

future are undoubtedly some of the greatest conceptual challenges facing the service. In some limited ways, the Air Force attempted to define its future vision related to these concepts. But even the Air Force's most strident statement ever regarding the importance of space to its future (*Global Engagement*)[109] said almost nothing about how the Air Force should transition and evolve to a space force or why it should do so.[110] Further, *Global Engagement* contained little on RMA, Transformation, and IO or how the Air Force should organize for these missions. Recognizing these difficulties, former Air Force Chief of Staff General Michael E. Ryan created the Aerospace Integration Task Force (AITF) in the spring of 1998 and tasked the AITF to develop approaches to help resolve many of these issues. The Air Force's May 2000 white paper, *The Aerospace Force,* and June 2000 vision statement, *Global Vigilance, Reach & Power,* are the fruit of the AITF and have brought the service full circle back to the aerospace concept.[111] Following the release of the latest edition of AFDD 2-2, *Space Operations,* in November 2001 and statements by Air Force Chief of Staff General John P. Jumper the same month, the Air Force is again emphasizing that "air and space" are separate operational mediums. Given these fundamental and enduring controversies surrounding military space, it is not an overstatement to say that the Air Force faces a battle for its very soul.

During the late 1990s, the Air Force's uncertain and hesitating movement forward on these issues helped to energize those who questioned the Air Force's overall stewardship of military space. One of the most outspoken critics, Senator Bob Smith (R-NH), created the Commission to Assess National Security Space Management and Organization (or Space Commission) as a part of the fiscal year 2000 National Defense Authorization Act. The Space Commission Report, parts of which are quoted earlier in this chapter, was submitted to the Secretary of Defense and Congress in January 2001. Due to its sweeping charter and powerful members, the Space Commission is the most important, and potentially the most influential group ever formed to examine these broad issues.[112] The Space Commission was created to challenge the status-quo in military space; it focused on the Air Force very carefully, and its very creation was an implicit critique of the Air Force's space stewardship.

The key recommendations of the Space Commission Report called for: raising the priority of national security space to a vital national interest; creating a Presidential Space Advisory Group; instituting closer and more regular coordination between the Secretary of Defense and the Director of Central Intelligence; setting-up an Under Secretary of Defense for Space, Intelligence, and Information; establishing a new four-star billet for the Commander of Air Force Space Command that is separate from CINCSPACE

and the North American Aerospace Defense Command; designating the Air Force as the Executive Agent for space within DOD; amending Title 10 of the US Code to assign the Air Force responsibility to organize, train, and equip for prompt and sustained offensive and defensive air and space operations; assigning the Undersecretary of the Air Force as the Director of the NRO and the Acquisition Executive for space; and beginning a Major Force Program to consolidate the military space budget.[113]

Secretary of Defense Donald Rumsfeld under the Bush (01) Administration recently accepted nearly all of these recommendations in his required assessment of the Space Commission Report for Congress. The only major change was that he did not request legislation to establish an Under Secretary of Defense for Space, Intelligence, and Information.[114] Most analysts believe that, despite its origins and desire for consensus, the Space Commission was quite successful in emphasizing the importance of space and refocusing America's attention on military space issues. In particular, it has strengthened the hand of the Air Force in military space. What remains to be seen is how well the Air Force will translate its now clearly dominant position for space stewardship.

CONCLUSION

This chapter began by providing a foundation to analyze military space issues by discussing three ways to describe spacepower: space activity sectors (civil, commercial, intelligence, and defense); military space mission areas (space support, force enhancement, space control, and force application); and military space doctrines (sanctuary, survivability, control, and high ground). It then briefly described the major organizations that are stakeholders for military space: the DOD, the Navy, the Army, the NRO, and the USAF, AFSPC, and USSPACECOM. Finally, it analyzed several of the most important current and near-term space policy issues: growing space commercialization and space as an economic COG; launch and range infrastructure; high resolution commercial remote sensing; PNT and global utilities; space and missile defense; and issues associated with RMA, Transformation, IO, and organizing for military space.

Throughout, the chapter has argued that spacepower is a complex concept that should be viewed in a comprehensive way rather than focusing on any one dimension or military space activity sector. For the near-term, increasing commercial use of space will have the greatest affect on military space capabilities. The US should closely monitor the actual trajectory of commercial space, use commercial instead of military systems whenever possible, and think carefully about the best way for military space forces to

protect and encourage the further development of the commercial space sector.

17
INTELLIGENCE SPACE PROGRAM

Dwayne A. Day*

INTRODUCTION

In action flicks and adventure novels, spy satellites swoosh into place and hover majestically over a target searching for rogue agents or terrorists. The reality, of course, is much more banal. America does indeed possess a fleet of spy satellites with impressive capabilities, but they are firmly bound by the chains of physics. They do not swoosh or hover. In fact, they orbit the Earth only through the actions of a massive bureaucracy, which for decades operated in secret, without being accountable to anybody but the President of the United States (US). This bureaucracy is in essence the third major branch of the American space program.

During the Cold War, observers of America's space effort, which were often collectively referred to as the National Space Program, assumed that the US had two programs: the civilian program run by NASA, with its Moon landings, Space Shuttle, and astronauts; and the military space program, run primarily by the Air Force. But the reality was that the US had a third space program, hidden behind the public front of the civilian program and the quasi-secret front of the military program. This third program was based upon the use of space for the collection of intelligence information. It was substantially isolated from the military space program and not prone to the same oversight and regulations of the military space effort.

This intelligence space program was run by an organization that was classified even to many within the military. It was an organization whose very name was secret. Publicly, this organization did not even exist. In the words of the Intelligence Community, it was "black," classified, and covert. This organization is the National Reconnaissance Office (NRO). It is the largest and most secretive intelligence organization to ever exist within the US government; larger than both the Central Intelligence Agency (CIA) and the National Security Agency (NSA). From the time of its inception until it was publicly declassified in 1992, the NRO spent billions of dollars and launched hundreds of rockets and yet nowhere was it mentioned in the federal budget. Never was it discussed on the floor of the US House or Senate.

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Indeed, rarely was it even discussed within the congressional committees that ostensibly were responsible for overseeing and funding it. Only its name could be found in secret-level documents, further details were classified at higher and more restricted levels.[1]

Despite its secrecy– in some cases because of it– this organization achieved remarkable things. It developed advanced technologies, overcame tremendous obstacles, achieved impressive management successes, and influenced the direction of American foreign policy. It was truly a remarkable organization that never needed to aspire to public relations concerns, for it simply had to meet the policy preferences of the US President.

Although officially it was a military organization, for years the NRO primarily served the needs of the President and the Intelligence Community first, and the needs of the military second. Its isolation and importance bred hubris– a belief in its own perfection. In the post-Cold War world, the NRO was jarred from its complacency and forced to begin thinking in new ways. Today, there are many competing demands for the NRO's attention and no general consensus on its future.

NATIONAL RECONNAISSANCE OFFICE

The NRO is a unique intelligence agency for several reasons. First, it is not a distinct organization in its own right. It is actually composed of parts of other organizations, primarily the CIA and the Air Force. An Air Force official heads the NRO. That Air Force official reports to the Secretary of Defense and the Director of the CIA, not to the Secretary of the Air Force or the military Air Force leadership, the Air Staff.

Second, the NRO, unlike most other intelligence agencies, is primarily an intermediary organization. It neither establishes intelligence requirements nor processes the intelligence data that it collects. For much of its early existence, intelligence requirements were established by the US Intelligence Board (USIB) and imagery was evaluated by the CIA's National Photographic Interpretation Center (NPIC). Signals intelligence was evaluated by components of the military services, such as Strategic Air Command (SAC) or the NSA. Today, intelligence requirements are established by the National Foreign Intelligence Board (NFIB), the National Imagery and Mapping Agency (NIMA) interprets imagery, and the NSA evaluates signals intelligence.[2]

These two factors– the NRO's internal structure and its position within the Intelligence Community– have had a strong influence on the evolution and operation of the NRO over the years. For decades there was an often bitter rivalry between the CIA and Air Force components of the NRO.

Although officially the USIB established intelligence requirements, it was up to the component offices of the NRO to establish what could be done with existing technology and to advance the state of the art of technology, and this often influenced the USIB's decisions about what to do. Furthermore, both the CIA and Air Force were part of the USIB, so they naturally had input to the requirements and had much involvement in the interpretation of the data. The relationship between the demand of requirements and the push of technological capabilities that advanced American satellite reconnaissance is therefore difficult to understand, even without the added burden of trying to peer into the shadows of this secretive program.

Dawn of "Big Black" Programs

The NRO was officially created in September 1961, but its origins lie with several cooperative projects conducted jointly by the CIA and the US Air Force in the 1950s. These were known by the code words AQUATONE and CORONA. In many ways, this early cooperation shaped the NRO organization. These projects established positive precedents for certain aspects of the NRO, such as the use of Air Force operations to provide cover for CIA activities, and pioneered the joint procurement of equipment. But their success also had a deceptive effect, since they implied that joint cooperation on projects had no drawbacks and that two organizations with similar but nevertheless distinct missions could cooperate. Thus, their success prevented government officials from recognizing the flaws inherent in any joint organization. The NRO might have been formally created in 1961, but in many ways it evolved into existence for several years before this date. It was an evolution beset with many problems.[3]

Prior to 1955, the CIA had no experience with large technical intelligence-gathering projects. The CIA's development of high technology projects was confined largely to the world of gadgets– radios, concealed weapons, encryption machines, and other devices used to support human agents working under cover. The majority of CIA operations consisted of traditional intelligence gathering and covert operations; technical equipment was needed only to support these missions.

In late 1954, at the suggestion of independent civilian advisors, US President Eisenhower gave the CIA the mission to develop a high-flying strategic reconnaissance aircraft. This development effort was code-named AQUATONE. Eisenhower's decision was an important one, for it essentially killed an Air Force effort to develop its own reconnaissance aircraft, although one that was primarily intended for wartime use.[4]

The CIA plane was to be used in overflight of Soviet territory during peacetime and because of this Eisenhower wanted it to be owned and operated by a non-military organization. Eisenhower's decision was also based upon two other factors besides the concern about the consequences of a pilot being lost over foreign territory. First, Eisenhower wanted the development project to be secret and did not trust the Air Force to keep it that way. Furthermore, Eisenhower wanted the intelligence product to be evaluated by the CIA, not the Air Force. Eisenhower felt that the military interpreted intelligence information to its own benefit and the CIA was a far more impartial observer that was sensitive to presidential interests.[5]

Eisenhower easily could have directed that the Air Force develop the aircraft and that the CIA evaluate the intelligence it produced. But he realized that the organization that operated the aircraft would have a major say in how it was used and the type of product it produced. It could design and operate it in a way that affected the intelligence data to its advantage and would not easily surrender the intelligence to another agency. By directing that the CIA build the aircraft, Eisenhower was attempting to ensure that the aircraft serve "national" (presidential and top-level civilian) interests, and not the interests of a single military service.[6]

Since the CIA had no real experience in developing large technical projects, the Agency relied upon Air Force experience. The Air Force was specifically enlisted to procure the engines for the aircraft, which it hid within a larger procurement account. But the CIA also used less Air Force support than one might expect. The director of the program established direct lines of control with the contractor, Lockheed. By doing so, the director cut out many of the middle levels of management that would normally be handled by Air Force officers. This streamlined management, making it both simpler and faster to reach decisions. It also dramatically improved accountability and secrecy. By virtually any standard of aircraft procurement, the AQUATONE program was successful.[7]

Within nine months the first aircraft was flying. The aircraft, designated U-2, had its first flight in July 1955. It made its first overflight of the Soviet Union in July 1956. The AQUATONE program was operational and returning high quality intelligence data before the Air Force had even expected to make its first flight with its now-canceled strategic reconnaissance aircraft.[8] The Air Force's canceled reconnaissance aircraft was scheduled to take at least twice that long and the typical Air Force aircraft development program took at least five years. All in all, the AQUATONE experience impressed virtually everyone who knew of the plane's existence and the program was hailed as an example of effective CIA-Air Force cooperation. It was this success that led to the next major cooperative technical effort between the two organizations, the reconnaissance satellite.

Beginnings of Reconnaissance Satellite

The Air Force had studied the subject of satellite reconnaissance starting in 1946, but it was ten years before the service formally started work on developing a satellite. In 1956 it created the WS-117L program to develop a nuclear powered satellite using a television camera to photograph the Earth. The television camera and nuclear power source were soon abandoned in favor of solar power and a film-readout technique– the satellite would photograph the target, develop the film, and then transmit it to the ground like a fax machine. This was a slightly easier approach to the task, but still very ambitious, and top civilian Air Force officials did not allocate significant funds to the project. This plan also had few supporters among the military and civilian Air Force leadership.[9]

In the fall of 1957, while WS-117L moved along incrementally, the Air Force office responsible for the satellite program began a separate effort to develop an even simpler satellite that abandoned the development and readout equipment and simply returned the film to the ground in a reentry capsule. While less complicated, this approach required new breakthroughs in reentry vehicle technology capable of keeping the film cool during reentry through the Earth's atmosphere. Because the overall WS-117L program was short on funds, the Air Force officer in charge of the satellite program took this new program to the CIA in the hopes that it too could be developed in the same way as AQUATONE. Before any decisions were made on this new program or new approach, the Soviet Union launched Sputnik in October 1957.[10]

Sputnik suddenly made space very popular in the Air Force. Generals who had previously taken a rather unenthusiastic approach toward space suddenly proposed numerous new programs from manned space planes to lunar bases. They were not very discriminating in their proposals– they wanted everything and they wanted it immediately.[11] The Soviet achievement also led to claims of a "missile gap." And, the US Intelligence Community struggled to learn if the Soviets would soon be able to deploy more Intercontinental Ballistic Missiles (ICBMs) than the US.

In February 1958, President Eisenhower reviewed the proposed reconnaissance satellite programs. Eisenhower allowed the Air Force's existing WS-117L program to continue, with more money, but directed that the CIA with Air Force support run the small recoverable satellite program in exactly the same way as AQUATONE.[12] Although Eisenhower's justification for placing the CIA and not the Air Force in charge is unknown, what is known is that top officials in the government considered the AQUATONE program to be an unqualified success in every area– management,

engineering, secrecy, and the quality of the intelligence data that it returned. It affirmed Eisenhower's reasons for choosing this unique management structure in the first place.

Over the next two years, the CIA led the development effort on a film-return spacecraft, which was known as CORONA. It was intended as an interim solution to operate only until a better replacement became available. CORONA remained a small, focused program, and suffered a string of launch failures, beginning in February 1959. The satellites were launched from Vandenberg Air Force Base on the coast of California. Many did not reach orbit and those that did never returned data from orbit.[13]

The Air Force also continued its own satellite reconnaissance effort, renaming the WS-117L program Samos. The Air Force planned to place SAC in charge of operating the Samos satellites once they completed development.[14] Initially Samos only involved one film-readout camera system, but this eventually grew to three. By 1959, the Air Force cancelled one of the early film-readout cameras, but then added a film-return mapping camera, and then another higher-resolution film-return camera as well as signals intelligence collection satellites known as Ferrets. Samos, which was entirely under Air Force control, became an increasingly complex collection of different cameras and spacecraft.[15]

By 1960, the two major satellite reconnaissance efforts were in trouble. CORONA had suffered twelve straight failures. Samos had yet to get off the ground. In May 1960, a U-2 aircraft was shot down over the Soviet Union halting further reconnaissance data on Soviet capabilities and making strategic satellite reconnaissance an urgent matter.[16] White House officials considered CORONA's problems to be largely technical and solvable. In contrast, they considered Samos' problems to be both in the design of the various spacecraft and in the management of the entire program. Eisenhower established a special advisory committee to address this issue. It returned its findings in August 1960, at the same time that a CORONA spacecraft had returned its first grainy reconnaissance images of the Soviet Union. The committee presented its formal report to the National Security Council (NSC).[17]

The committee did not address CORONA. Not only was that program now moving toward success, but it was also more highly classified than Samos– classified at a level above most members of the NSC, including Vice President Richard Nixon. However, the committee had significant things to say about Samos. First, it stated that the film-readout approach, which was then the primary emphasis for Samos, was too ambitious and too limited, as it would return only a handful of pictures each day, and should be reduced to no more than a technology demonstration. Second, the committee also stated the Samos was limited in its capabilities. It should continue on,

but would not provide the type of intelligence that was desperately needed– intelligence on Soviet ICBM capabilities. Third, it stated that what the country now needed was a satellite replacement for the U-2 capable of seeing objects on the ground at resolutions of 0.5 meters. None of the reconnaissance satellite cameras in existence or development at the time could accomplish this. The Air Force should develop this new spacecraft, which was soon named GAMBIT. Whereas CORONA was a "search" system, GAMBIT was a "spotting" satellite, like the sighting scope on a rifle.

Finally, the committee stated that before the Air Force could do any of these things, the Samos program office needed to be completely redesigned. Instead of reporting through the traditional military chain of command to the Air Staff, the reconnaissance satellite program office was now to report directly to the civilian Secretary of the Air Force, who would report to the Secretary of Defense. The military officer in charge of the reconnaissance program would not take orders from senior generals, but from a civilian. No other Air Force office would have direct input into the design or management of the new spacecraft. SAC would not operate them.[18]

Although worded in typical bureaucrat language, this was a stunning rebuke for the Air Force. With the U-2 no longer capable of flying over the Soviet Union, satellite reconnaissance had now achieved extreme urgency and the committee was stating that the traditional Air Force method of managing programs could not be trusted. Furthermore, the Air Staff– the Air Force's top military leadership– was removed from any control and was even placed on a "need to know" basis for the program. Even more significant, SAC would now have to get in line for satellite information, just like everyone else.

President Eisenhower concurred with the committee's recommendations. The decision to separate the management of reconnaissance from Air Force control was in keeping with the earlier U-2 and CORONA decisions. It was also reinforced by the continued controversy within the Intelligence Community over the existence of the "missile gap." Air Force leaders continued to argue that the Soviet Union had far more ICBMs than the CIA claimed.

Satellite reconnaissance had now been reoriented to serve national purposes, not military needs. The photographs were now intended for CIA, White House, and Defense Department officials, not Air Force military officers. The military philosopher Karl von Clausewitz had famously said that war was too important to be left to the generals. President Eisenhower was now stating that satellite reconnaissance was too important to be left to the generals.

Along with these decisions came an order to create a new security process to protect information. This was designated BYEMAN and it was

above top secret. Persons in the government and military who had top secret security clearances would not be allowed access to information on reconnaissance satellite technology and operations unless they also had a BYEMAN clearance. Over time, this category evolved to include system vulnerability and survivability information, development and key design information, industrial and contracting relationships, funding and budget matters, sensitive launch information and operations, and command and control operations.[19]

In September 1960, the Air Force created the Office of Missile and Satellite Systems. However, instead of reporting to the Secretary of the Air Force as originally planned, it reported to the Under Secretary of the Air Force.[20] There were now essentially two reconnaissance satellite management groups– a CIA one that managed the payload for the CORONA and an Air Force one, which managed everything else, most importantly the GAMBIT spotting satellite. Initially, the two programs cooperated with virtually no formal agreements given the close ties between the respective directors of each program.[21] A small Navy satellite intelligence operation had also started up after Sputnik and achieved some success, but its efforts were too minor to merit much attention from the Air Force and CIA.[22]

But there was no way that this arrangement would survive for long. First, any inter-departmental cooperation that rests primarily upon the individuals running the program is fragile. If they leave– few government officials stay in any post beyond one presidential term– the cooperation falls apart. Second, the CIA's work on CORONA was only a small part of the overall effort; the Air Force launched the rockets, operated the satellites on orbit, and retrieved the film. As the CORONA program became more successful, there were those in the Air Force who began to resent the claim that the CIA was primarily responsible for the success.

Further compounding the problem was the fact that the CIA was not exerting significant new effort into new satellite development. Although the CIA was funding an upgrade to CORONA, it had not begun to propose other types of satellites or even an eventual replacement. Instead, the majority of the CIA's new technical development effort was focused upon a Mach 3 reconnaissance aircraft known as OXCART, originally intended to replace the U-2, but now totally unsuited for overflight of the Soviet Union. In contrast to the CIA's stagnant efforts on satellite reconnaissance, the Air Force was working on a number of satellite programs– the GAMBIT and several spin-offs of the Samos program. Finally, CORONA still had the reputation of an interim program that would eventually be replaced by something better, an Air Force satellite then under development known as the Samos E-6. Thus, some Air Force officials expected that the CIA would eventually leave the satellite business altogether.

In 1961, with the election of US President John F. Kennedy, the CIA's role in satellite reconnaissance became more fragile. The 1961 CIA effort to land anti-communist insurgents at the Bay of Pigs in Cuba failed miserably. More importantly, the CIA had used the U-2 to prepare for the Bay of Pigs. This angered Kennedy's top intelligence advisors as technical intelligence collection activities should not be risked over the CIA's covert operations. Given this concern, the Kennedy Administration felt that a more formal arrangement for satellite reconnaissance was required.

On 1 September 1961, a DOD directive established the NRO. The NRO was not a formal organization in the real sense. It was primarily an agreement between the CIA and the Air Force to cooperate in what they were already doing. The Air Force provided the NRO's small staff. Most of the work of the NRO continued to be performed by the Air Force Samos satellite office– now renamed the Air Force Office of Special Projects– and by contractors, primarily Lockheed, Itek, Kodak, and the Aerospace Corporation.[23] The NRO established three separate programs; Program A was the Air Force Office of Special Projects; Program B was the CIA office; and Program C was the Navy office at the Naval Research Lab. There were no rules that stated that a specific program office had to work on only certain types of activities. In 1961, the CORONA missions finally put to rest the myth that the Soviet Union was fielding hundreds of ICBMs. This proved the wisdom of Eisenhower's decision to place CORONA and national imagery interpretation under civilian control.

While all of this was happening, the Air Force also ran the military space program. This consisted of infrared early warning satellites and communications satellites, and experimental satellites in cooperation with NASA. The Air Force also studied the military role of placing man in space and undertook several programs intended to evaluate this subject. This Air Force space program was not the NRO. Albeit the NRO used many of the same rockets, launch pads, and tracking facilities of the military space program, it was separate from this program. The people who managed NRO satellite programs had virtually no involvement in other Air Force space programs, and they took direction from an entirely different set of people starting with the President of the US. With the President as their prime customer and benefactor, the NRO possessed a great deal of clout.[24]

Evolution of "Big Black"

In 1962, the CIA was split up into separate components to deal with covert action and technical intelligence. By 1963, reconnaissance was viewed

as the CIA's most important intelligence mission and it required further funding and effort. It was argued that the Air Force's track record with regard to space had been unimpressive. Samos had proven to be a total disappointment– of the various different camera systems the Air Force had started developing several had been canceled before ever leaving the ground and a few others succeeded in orbit. Further, the Air Force had shown a tendency to become distracted with other space missions, losing sight of the space reconnaissance mission.

As such, the CIA began building a powerful research and development (R&D) office. This office relied upon contractors, such as Lockheed, far less than it had for the U-2 and CORONA programs. The newly formed CIA Directorate of Science and Technology had the resources and personnel to take on the other directorates at CIA and also to take on the Air Force Office of Special Projects within the NRO. This was a tectonic shift in the world of American reconnaissance. Instead of cooperating to build the best systems, the CIA and Air Force now began to compete, often proposing different satellite designs to achieve the same mission.

Even though CORONA had initially been an interim program, its replacement, Samos, had never panned out, and CORONA was now operational; in 1960 its mission success rate had been 25%, in 1961 50%, and in 1962 75%. For the NRO, it made sense to transfer control of this operational program over to its Air Force component. The Air Force was responsible for the majority of the work for each CORONA mission and the Air Force had the office necessary to carry out all of this work. Also, transferring the authority of the payload to the Air Force could conceivably lead to greater efficiency for the NRO.[25]

But the Air Force's efforts to take over the program– efforts that enjoyed the support of both the Secretary and Deputy Secretary of Defense– ran into staunch opposition from the CIA. It was seen as nothing other than a military attempt to push the CIA out of the reconnaissance business entirely and CORONA was ripe for the taking.[26] As a result, the CORONA contract fell into dispute. Lockheed, which was responsible for the Agena rocket used to place CORONA and GAMBIT in orbit and overall payload integration of the CORONA spacecraft, chose not to accept money from either the CIA or the Air Force for nearly a year. Management at Lockheed knew that by favoring one agency of the government it risked alienating the other, and so it prudently decided to not do anything until the bureaucratic and political struggle subsided.

Finally in 1963, GAMBIT began flying and was successful right from its first launch. CORONA and GAMBIT soon began operating in concert, with approximately one of each launched every month. CORONA would search large areas of the Soviet Union looking for new activity and GAMBIT

would later focus on them, showing a much higher level of detail in the photos it returned from orbit.

Also, the CIA initiated two new satellite research programs. One was an evaluation of capabilities needed for a successor to CORONA, and the second was a geosynchronous signals intelligence satellite to listen in on Soviet missile tests. The Director of the NRO was not even aware that these programs were underway; NRO officials were told that because they were CIA programs, NRO officials did not have the security clearance to know of them. The CIA felt that the NRO Director should only follow the direction of the Secretary of Defense and the Director of the CIA; the CIA was not willing to allow low-ranking Defense Department and Air Force officials to make important decisions concerning satellite reconnaissance. In other words, the NRO should manage the satellite intelligence program and not direct it (i.e., approve or disapprove of programs).[27]

After a protracted battle over these issues, the DOD and CIA signed an agreement in 1965, which established that the NRO report to an Executive Committee consisting of the Secretary of Defense and the Director of the CIA.[28] In essence, the CIA position prevailed as the Executive Committee had to approve all NRO programs. The NRO Director now had limited authority over NRO programs as preferred by the CIA.

Bigger and Bolder Satellite Reconnaissance

The CIA effort to develop a follow-on to CORONA resulted in a preliminary satellite design known as FULCRUM, which was eventually renamed HEXAGON. The CIA's geosynchronous signals intelligence satellite was named RHYOLITE. HEXAGON first flew in 1970 and was immediately successful. RHYOLITE first flew in 1971 and was also successful, returning information on Soviet missile tests. Sometime after both of these programs were started, the CIA began a third research effort to develop a real-time reconnaissance satellite.[29]

The abandoned Samos program had used a film-scanning technique that took a picture on film, developed it in orbit, scanned it, and transmitted the images to Earth. This system was slow and could only return about three-dozen images per day– all at low resolution. CORONA and GAMBIT, on the other hand, could both take many more pictures, but these were on film that stayed in orbit for several days until the satellite was finished with its mission. The film was then ejected, reentered the atmosphere, and recovered. It took approximately five days from the recovery of the film to the initial analysis by photo-interpretation specialists. Because of this delay, CORONA and

GAMBIT imagery was useless for immediate tactical planning purposes; it had no utility in a crisis. The imagery was primarily used for strategic planning. It was used to determine the nature of the Soviet threat and how the US should respond to that threat.

A real-time system that could return imagery within a few minutes or hours after a target was photographed could be immensely useful for both political and military leaders. In particular, the military could use such a satellite to fight a war, making decisions based upon the changing battlefield. The CIA's Directorate of Science and Technology funded a research effort to develop a system capable of turning an image directly into electronic impulses using a means other than the conventional low-resolution television technique. By the early 1970s this effort achieved operational success.

The Air Force Office of Special Projects– the Air Force NRO component– also continued to work on new and improved satellite designs. It fielded a number of small electronic intelligence satellites for gathering data on Soviet radar signals. By the mid-1960s it funded the development of a communications intelligence collection satellite known as CANYON that was launched to geosynchronous orbit in 1968. It also funded an upgraded version of the GAMBIT spotting satellite known as the KH-8, which was first launched in 1967. Finally, the Office of Special Projects funded a system that would combine the GAMBIT and Samos film-readout satellites to provide a near-real-time capability. This was called Film Read-Out GAMBIT, or FROG, and it was under development in 1966. Its capabilities were limited, however, and it would only be able to return a small number of photographs during each pass over the Soviet Union.[30]

Even though DOD approved FROG in 1970, a meeting of the President's Foreign Intelligence Advisory Board (PFIAB) in 1971 concluded that a CIA real-time data reconnaissance system was preferable. As a result, the Air Force's FROG was canceled and a new system, known as the KH-11 KENNAN, began.[31]

KENNAN, which is still classified, was a large electro-optical satellite that underwent a problematic development and apparently ran considerably over-budget. The first KH-11, which looked much like the Hubble Space Telescope, was launched in late 1976. It was declared operational by US President Jimmy Carter on his first day in office.[32] Its electro-optical system took images over the Soviet Union and relayed them through high-flying Satellite Data System (SDS) communications satellites back to a location outside Washington DC. The images were processed and a photograph could be on the President's desk within an hour. Despite this capability, the HEXAGON and the KH-8 GAMBIT remained in service until the mid-1980s, providing photos of larger areas and with higher resolution.

The KH-11's near-real-time capabilities were immensely useful, the primary beneficiary of this rapid increase in the speed of reconnaissance photography was the President and his top advisors. Military leaders– and the uniformed rank and file– still had relatively limited access to satellite reconnaissance photos. This was due partly to technology– the equipment needed to exploit the imagery was complex– and partly due to policy. Because satellite imagery was such a powerful tool, it was jealously guarded and senior intelligence officials worried that making it available to a wider range of users risked having it leaked to the Soviet Union.

By the early to mid-1970s, the NRO's budget was approximately one billion dollars a year, which was less than a third of the budget for NASA. Unlike NASA, however, NRO experienced very little oversight. Although congressional armed services committees were made aware of the NRO's existence in the late 1960s, they did not interfere in a program that their members viewed as highly successful, extremely important, and largely the purview of the President of the US.

Despite attempts to preserve the cloak of secrecy around the NRO and its operations, the NRO suffered from several serious security breaches. Spies provided the Soviet Union with extensive information on the RHYOLITE satellite and the KH-11. In the latter case, the Soviets purchased for $3000 a complete technical manual for the US top intelligence satellite.[33] While the American public was kept in the dark about the NRO– its very name was still secret– the Soviet Union knew a great deal about what it did.

By the late 1970s, as the result of a number of embarrassing revelations about American covert actions in Guatemala and Cuba conducted by the CIA, standing intelligence oversight committees were established in the US House and Senate. These permanent committees paid closer attention to the actions of the NRO than the armed services committees had before them. But their ability to understand the actions of the NRO was limited, for it conducted highly technical activities. NRO officials were also able to impress their congressional overseers with reconnaissance products. Although there is very little information available on congressional oversight of the NRO, there is no reason to believe that it was effective as a tool of public accountability during this time period or throughout the 1980s.[34]

SATELLITE RECONNAISSANCE AND THE SPACE SHUTTLE

In 1969, NASA and the Air Force began defining the requirements for NASA's next launch vehicle program, the Space Shuttle. The Air Force soon established several requirements that the Shuttle had to meet in order for

the military to endorse the project and agree to fly its satellites on it. This implied that the Shuttle payload bay had to be sixty feet long, fifteen feet wide, and be capable of lifting up to 60,000 pounds into low Earth orbit. The Shuttle also had to be capable of launching into polar orbit.

A "national security payload" dictated the Space Shuttle's payload bay and its lifting capability. This payload was a reconnaissance satellite. The Space Shuttle had to be capable of lifting the largest satellite then on the drawing boards. This was the NRO's KH-9 HEXAGON, referred to as "big bird." With its nose pointing down at the Earth, its two high-powered cameras imaged vast swaths of ground at high resolution. The first KH-9 went into orbit in 1971, before the Shuttle design was even finalized. Although a KH-9 never flew on the Space Shuttle, it nevertheless formed the template upon which the Shuttle was designed.

Despite the fact that a NRO payload dictated the size and capabilities of the Space Shuttle and thus, had a profound effect upon the evolution of the American civil space program, the NRO itself was not directly involved in these deliberations. Throughout the 1970s, the Air Force leadership monitored NASA's work on the Shuttle and slowly began the Air Force's own shuttle-related programs to meet Air Force and NRO needs, such as beginning work on extensive Space Shuttle facilities at Vandenberg Air Force Base to enable the Shuttle to fly to polar orbit, and building a secure mission control center in Colorado. But Air Force leaders, particularly the military leadership of the Air Staff, remained wary participants in the Space Shuttle program.

The NRO leadership was outright skeptical of the Space Shuttle and preferred to continue using the Titan III launch vehicle that was already carrying the bulk of NRO payloads. Some NRO payloads were given a "dual capability," which enabled them to be launched on either the Shuttle or a Titan III. However, in 1977, the Secretary of the Air Force, who was also serving as Director of the NRO, ordered that all NRO payloads be converted to fly on the Space Shuttle and that dual capability design be eliminated. The intent was to allow for the Air Force to phase out the Titan III. This decision made all national security payloads, including the expensive and secretive intelligence satellites, dependent on the Space Shuttle. The implication was that within the space of a few years NRO satellites would only be capable of Shuttle launches, making the secretive NRO reliant upon NASA for access to space.[35]

Though the details of these decisions are still classified, it is clear that the NRO was a reluctant partner in this "one shuttle launch" policy. Many NRO engineers did not want to have to redesign existing satellites to enable them to fly aboard the Space Shuttle, with its different flight characteristics. There was a widespread view within both NRO and the Air Force that the

Space Shuttle was not reliable. By the early 1980s, after the Space Shuttle began flying, there were numerous hints that it was not going to meet its promised performance goals. In particular, it was not able to meet launch dates or flight rates. Further, higher than anticipated operating costs and the vagaries of government accounting meant that the Shuttle cost the Air Force more per flight than the Titan III. In 1983, the Secretary of the Air Force decided to procure an additional batch of upgraded Titan III rockets to "complement" the Shuttle. This would only be possible if the dual capability was once again designed into the satellites and this presumably happened for some– although not all– of the satellites then being procured by the NRO.[36]

The NRO also experienced another concern when its highly classified payloads began flying on the Shuttle in 1985– publicity. There was no way that a manned civil Space Shuttle launch carrying a top-secret payload was going to avoid some degree of publicity. The press speculated widely on the payload and leaks eventually made the pages of the *New York Times.* For an agency accustomed to going almost completely unnoticed for over two decades, it was a new experience.

But the real problems with this policy came with the Challenger accident in January 1986. The grounding of the Space Shuttle fleet left the NRO with a handful of satellites that could only be launched aboard the Shuttle. A Titan rocket failure only a few months later left the US with only a single photoreconnaissance satellite in orbit. It took several years for the NRO to recover from the Challenger accident, develop a plan to procure more Titan rockets, the upgraded Titan IV, and move all of its payloads off of the Shuttle.[37]

Despite its uncomfortable relationship with NASA and the Space Shuttle, the 1980s were growth years for the NRO. US President Ronald Reagan's defense build-up pumped billions of dollars into the NRO, allowing it to begin several new major intelligence satellite programs, most of which remain deeply shrouded in secrecy. With this increase in money came more clout– the NRO always lurked in the shadows of major space policy decisions, unmentionable, but always influential.

POST-COLD WAR WORLD

In early 1991 the US led a coalition of nations in Desert Storm, driving Saddam Hussein's Iraqi forces out of Kuwait. Desert Storm is often referred to as the "first space war" where satellites played a significant role in the conflict. The NRO's satellites also contributed a great deal of intelligence information to coalition forces. By this time the NRO was operating an

impressive fleet of approximately two-dozen satellites for gathering imagery, signals collection, and communications. But the NRO's fleet had not been designed to provide the kind of information that American commanders found useful. Military officers found the existing space intelligence program to be unwieldy and ill-suited for military needs, particularly when it came to processing the imagery that the reconnaissance satellites returned.

As a result of these criticisms and the end of the Cold War, the Secretary of Defense and Director of the CIA agreed to publicly announce NRO's existence in 1992. This decision, coupled with the downgrading of secrecy concerning satellite imagery, allowed the NRO to reach a broader number of customers within the military. Now a pilot or a tank commander with a generic secret clearance could obtain satellite photography of his target without hassle. Several years later, US President Clinton declassified the CORONA satellite program and the NRO gradually became more open about its activities, to the point where it became relatively less secret than either the NSA or the CIA.[38]

Defense and CIA officials also made a major decision about the organization of the NRO. The NRO's component offices (Programs A, B, and C) had long been ordered along institutional lines. Various functions in these offices were now consolidated into three separate directorates to manage imagery, signals intelligence, and communications, all located in the same facility near Washington DC. This bureaucratic reform represented a major step toward a more cohesive NRO. In addition to these policy changes, the NRO also made some programmatic changes, beginning new efforts to develop ground-based terminals for utilizing its products and making changes to its satellites to provide more useful data. The NRO's leaders attempted to shift the organization's focus from serving just "national" leaders, such as the President and other senior officials, to also serving the "warfighter."[39]

In 1996, the Secretary of Defense and Director of the CIA agreed to merge the CIA's NPIC and the DOD's Defense Mapping Agency into NIMA. The stated purpose of this move was to improve the consolidation of imagery and "geospatial information" (the location of targets on the ground) into integrated electronic products that could be easily presented to warfighters. In the course of this merger, many former CIA imagery analysts left NPIC, gutting the nation's imagery analysis resources.[40]

The switch to the Titan IV rocket for most NRO payloads, which began in the early 1990s, had also been a policy failure. Ironically, the Titan IV proved no more reliable and no less expensive than the Space Shuttle. The NRO had independence from NASA, but did not gain reliability or save money in the process. As defense budgets decreased after the Cold War, the NRO also began looking to build smaller satellites capable of flying on smaller and cheaper rockets.

Several years after the NRO became public, it experienced the downside of an overt existence– public scandal. The first scandal concerned the NRO's new headquarters facility. Congressional leaders claimed that the NRO had not kept Congress fully informed of the cost of the facility and used the opportunity to publicly humiliate the NRO leadership.[41] The following year, a far more serious scandal erupted when it became public that the NRO, whose secret budget was then around $6.5 billion, had accumulated over $4 billion in unspent funds. This money, which should have been returned to the US Treasury, was instead lying dormant in various covert accounts in the NRO's accounting system. The NRO's already strained relationship with Congress was shattered and the President fired the top leadership at the NRO.[42]

Over the next several years, the NRO struggled to repair its relationship with Congress and the President. It also began a new imagery program intended to better satisfy the needs of the military, through more consistent coverage of targets, and Congress, by costing less.[43] This plan, known as the Future Imagery Architecture (FIA), ran into a number of problems, including the complaint that NIMA was not spending enough money to actually process the imagery that the satellites would produce.[44]

The NRO came under additional criticism in a 2000 *Report of The National Commission for the Review of the National Reconnaissance Office.* A congressional committee criticized the increased openness of the NRO and called for a return to the intense secrecy that marked its early years– which also shielded the NRO from congressional oversight. Furthermore, this congressional committee also called for a return to the focus on serving the needs of the President, not the warfighter, thus reversing the post-Cold War trend toward expanding the customer base for satellite intelligence information.[45]

CONCLUSIONS: FIXING THE NRO

There is no clear consensus on what needs to be done to "fix" the NRO, nor a consensus that it needs fixing at all. In 2000, several high-level studies were conducted that concerned aspects of the NRO. Some of the suggestions– such as increasing the status and power of the NRO Director within the defense bureaucracy– seem relatively minor, but may help clarify the purpose of the organization. Others, such as returning the NRO to its early Cold War roots, when it was extremely isolated and had relatively little oversight, seem to contradict the reality of increasing demand for NRO

services and the completely different strategic environment of the post-Cold War world.

CONCLUSION

SPACE POLITICS AND POLICY: FACING THE FUTURE

John M. Logsdon*

The essays in this volume individually and collectively do an excellent job of laying out the many dimensions of space activities to date, provide various conceptual frameworks for the analysis of those activities, and guide the reader to the body of policy-oriented literature that has grown up around the space sector. Taken together, they comprise an extremely valuable resource for understanding the political and policy aspects of the space sector as its development has gone forward.

This concluding chapter reflects on how the policy issues related to space activity have changed and continue to change today. The general perspective is that new approaches and new understandings are needed, ones that will challenge not only those who have been working on space issues for some time, but also the new generation of space analysts who will read this and similar works. This challenge lies in learning and applying multiple frameworks to the analysis of space policy.

The thoughts expressed in this concluding chapter reflect the views and "authority" of someone who has observed space affairs close-up, but from some analytical distance, since the beginnings of the space age.[1] These thoughts are a product of the "golden age" of space development as exemplified by the Sputnik launches in 1957, Yuri Gagarin's pioneering flight in 1961, John Glenn's three-orbit mission in February 1962, and the Apollo lunar landing of 1969.

ONCE WE WENT TO THE MOON

Space politics and policy is a product of this golden age of space development, when President Kennedy committed the US to sending Americans to the Moon. The US was taking the lead in bringing the benefits

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of satellite communications to the world, while ensuring US political and industrial leadership in this new area of commercial activity, and NASA was mobilized to achieve space "preeminence" that was Administrator James Webb's highest priority objective. Every mission seemed to achieve something new and exciting, and the Mercury and Apollo astronauts were nationally known heroes. NASA had begun to send spacecraft to Venus and Mars, and was getting back from the Moon close-up images of its forbidding landscape. Working on space policy issues at the time was the chance to share vicariously in the adventure of exploration.

Such an experience is not likely to be replicated for some time to come. There is no compelling reason to send people once again beyond Earth orbit. A return to the Moon and missions to Mars are at least several decades away. This means that future space analysts will primarily focus their attention on repetitive activities in Earth orbit, carried out for research, commercial, public service, or military reasons, with an occasional robotic deep space science or exploration mission. These are all valuable activities certainly, but not ones to excite the imagination.

The US civilian space program, as most people understand it, peaked on 20 July 1969 with the Apollo 11 lunar landing and has been on a long, sometimes slow, sometimes precipitous, decline, coasting on the momentum of Apollo ever since. The exceptions are the robotic program of Solar System exploration, which continues to provide both scientifically valuable data and publicly attractive images, and the achievements of the Hubble Space Telescope. Back in the 1960s, almost everything about space was new. The space program operated largely outside the realm of "normal" politics; it was an instrument of national policy, where bureaucratic and advocacy group influences were secondary.

It is even questionable whether the benefits that NASA provides to the country at large today justify a $15 billion budget, a budget with approximately half of the spending power of the NASA budget at Apollo's peak funding.[2] Currently, the primary determinants of NASA's budget are a combination of incrementalism, advocacy group influences, and bureaucratic politics. The material presented in this book has great utility in understanding those factors, and to the degree they remain important influences in space politics and policy, they will remain quite relevant.

In the euphoria produced by the first lunar landing, to those of us close to the space program anything seemed possible. On 4 August 1969 Wernher von Braun presented to Vice President Spiro Agnew NASA's plan for an initial human mission to Mars in 1982. Agnew had been charged by President Nixon with chairing a "Space Task Group" to prepare "definitive recommendations" for what should follow Apollo.[3] When Agnew and the rest of the Space Task Group let it be known to the White House that they

intended to recommend such a fast-paced, expansive post-Apollo program, they were told that such a suggestion would not be acceptable. The Nixon Administration was not interested in significant new investments in space.

NASA in 1969 was honest in its ambitions, and learned from the experience that honesty in program terms was not politically prudent. Over the next twenty-plus years, NASA has told its supporters almost anything they wanted to hear in order to get its major programs approved. The results are the Space Shuttle and space station programs that promised to be all things to all people. Trying to implement them, NASA lost much of its technical and managerial integrity.

The nadir in NASA's political credibility came with the Agency's response to President Bush's 20 July 1989 call for a Space Exploration Initiative (SEI) focused on completing the space station, returning to the moon, "this time to stay," and then sending people to Mars.[4] NASA presented an uninspired, self-serving, and very expensive plan for achieving these goals to the White House,[5] and was essentially told to go away.[6] As Roger Handberg suggests in this book, space had become by 1989 "a secondary public policy priority." This experience convinced the White House that NASA could not even carry out programs aimed at second-order priorities very well. A decade later, this concern has been reinforced with the current cost and management issues facing the International Space Station (ISS).

REINVENTING THE SPACE PROGRAM

By 1992, the Bush White House had despaired of NASA's current leadership being able to revitalize the organization, and brought in as administrator an outsider to civilian space, Daniel Goldin, with a mandate to reinvent the organization. In his ten-year tenure, Goldin made significant progress towards this objective, but left the task incomplete. NASA, with its close links to congressional and industrial supporters that developed in the 1970s and 1980s, has proven to be very resistant to change.

Nonetheless, Goldin understood and advocated some of the fundamental shifts needed if NASA is to become a relevant twenty-first century organization. Goldin pushed to make NASA an agency developing cutting edge capabilities in areas like nanotechnology, biotechnology, and information technology, and taking the lead in applying those capabilities to space efforts aimed not only at science and exploration, but also to commerce and national security. If those shifts do take place successfully, they will be a lasting Goldin legacy. Moreover, they will also require a new approach to the understanding of space politics and policy.

The kind of NASA that will emerge if the changes started by Goldin continue will be difficult to understand completely if space is only treated as a separate area of government activity. Space also needs to be examined in terms of mainstream public policy concerns. In order for NASA to remain relevant, it must join that mainstream. If it does not, it is likely to gradually fade into irrelevance. The same might be said for those aspiring to the understanding of space politics and policy, if they do not prepare themselves for the space issues of the future.

A NEW CONTEXT FOR SPACE

One particularly cogent analysis of the new situation in space is a November 2000 report to the Director General of the European Space Agency (ESA) prepared by three widely experienced "wise men." The report comments on the future of space activities in Europe, however, it is instructive to read the following excerpt substituting "United States" for "Europe":

> For long, space was seen as a special, separate, and exclusive activity, very much apart from other types of activities. During the initial decades of space activities, this was to a large extent true. And, as far as it relates to the unending quest for improving human knowledge about our universe and origins, as we reach further and further in outer space it will indeed remain so.
>
> But now, space is coming down to Earth. Increasingly space-based assets are integrated with other key developments in our societies. ...we can no longer see space and space policy as separate from other European activities.
>
> We are convinced that space policy in Europe must enter a new phase, where it is no longer seen as an exclusive and separate activity, but where it is an integrated aspect of the overall efforts of the countries and institutions of the European Union.

The implications of this perspective for students of space politics and policy are profound. Not only must they learn about the space sector; they must also understand how it is linked to other societal activities in both the public and private sectors; they must be able to discuss the pros and cons

of government-industry partnerships to employ space assets for a variety of purposes. Also, they must understand which applications of space capabilities, for providing security, protecting the environment, generating widely used new technologies, carrying out public functions, such as infrastructure development, and forming the basis of new industries, like obtaining energy for Earth from solar power satellites, make sense and which do not. A future space policy analyst will have to discuss the economics of space-based versus terrestrial information transmission systems, the relative advantages of satellites and unmanned aerial vehicles for locating targets on a battlefield, whether there is a real market for one-hour package delivery across the Pacific or for a viable space tourism business.

The contents of this book provide insightful ways to understand the internal operations of the space sector and provide the basis for a "space push" analysis of future space activities. But that space push, to be successful, must be consistent with the demand for space capabilities coming from a wide variety of users, both governmental and private sector ones. Understanding the perspectives of various users has not been the strong suit of the space community, nor of space policy analysis. For space policy analysis to be relevant to the emerging issues of the twenty-first century, it needs to evolve in its breadth of concerns and methodological sophistication. Thus, subtitling this book *An Evolutionary Perspective* seems particularly appropriate and useful to advancing the analysis of space politics and policy.

NOTES

CHAPTER 1. HISTORICAL DIMENSIONS OF THE SPACE AGE

1 This still seems very much the case, in spite of a concerted effort by professional historians to move in a more scholarly direction. The only journal in the US dedicated to space history, the *Quest: The Journal of Space History,* for all of its very real positive attributes, is focused largely on the evolution of the artifact.

2 There are some first class earlier studies that prove the exception to the rule. For instance, the NASA History Series has published a series of high-quality, balanced, authoritative volumes on the history of space exploration. These works, were they more theoretically-oriented, might be appropriately considered pioneers in the "New Aerospace History."

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4 Wernher von Braun, Frederick I. Ordway III, and Dave Dooling, *History of Rocketry and Space Travel* (New York: Thomas Y. Crowell Co., 1986).

5 Representative examples of these works include Frederick I. Ordway III and Mitchell R. Sharpe, *The Rocket Team* (New York: Thomas Y. Crowell, 1979); Ernst Stuhlinger and Frederick I. Ordway III, *Wernher von Braun: Crusader for Space,* 2 vols. (Malabar: Robert E. Krieger Company, 1994); Frederick I. Ordway III and Randy Liebermann, eds., *Blueprint for Space: From Science Fiction to Science Fact* (Washington DC: Smithsonian Institution Press, 1992); Frederick C. Durant III, ed., *Between Sputnik and the Shuttle: New Perspectives on American Astronautics* (San Diego: American Astronautical Society, 1981); Frederick C. Durant III and Ron Miller, *World's Beyond: The Art of Chesley Bonestell* (Norfolk: Donning, 1983); and Walter Dornberger, *V-2: The Nazi Rocket Weapon* (New York: Viking, 1954).

6 As examples, see in particular, William B. Breuer, *Race to the Moon: America's Duel with the Soviets* (Westport, CT: Praeger, 1993); and Marsha Freeman, *How We Got to the Moon: The Story of the German Space Pioneers* (Washington DC: 21st Century Associates, 1993).

7 John Glenn, Jr., "The Next 25: Agenda for the US," *IEEE Spectrum* (September 1983): 91.

8 See the analysis in Richard Slotkin, *Gunfighter Nation: The Myth of the Frontier in Twentieth Century America* (New York: Atheneum, 1992), 489-97.

9 Washington DC: NASA Historical Reference Collection, NASA History Office, Wernher von Braun, "The Challenge of the Century," 3 April 1965, Wernher von Braun Biographical File.

10 Patricia Nelson Limerick, "The Final Frontier?" *Wilson Quarterly* 14 (Summer 1990): 82-83.

11 As examples, see these recent general works, William E. Burrows, *Exploring Space: Voyages in the Solar System and Beyond* (New York: Random House, 1990); Michael Collins, *Liftoff: The Story of America's Adventure in Space* (New York: Grove Press, 1988); Michael Collins, *Mission to Mars: An Astronaut's Vision of Our Future in Space* (New York: Grove Weidenfeld, 1990); Patrick Moore, *Mission to the Planets: The Illustrated Story of Man's Exploration of the Solar System* (New York: W.W. Norton and Co., 1990); Peter Bond, *Reaching for the Stars: The Illustrated History of Manned Spaceflight* (London, England: Cassell, 1993); Ron Miller, *The Dream Machines: An Illustrated History of the Spaceship in Art, Science and Literature* (Malabar: Robert E. Krieger Co., 1993); Carl Sagan, *Pale Blue Dot: A Vision of the Human Future in Space* (New York: Random House, 1994); Alan Shepard and Deke Slayton, *Moonshot: The Inside Story of America's Race to the Moon* (New York: Turner Publishing, Inc., 1994); Stanley Schmidt and Robert Zubrin, *Islands in the Sky: Bold New Ideas for Colonizing Space* (New York: John Wiley and Sons, 1996); G. Harry Stine, *Halfway to Anywhere: Achieving America's Destiny in Space* (New York: M. Evans and Co., 1996); Robert Zubrin, *The Case for Mars: The Plan to Settle the Red Planet and Why* (New York: The Free Press, 1996); and Martin Caiden and Jay Barbree, with Susan Wright, *Destination Mars: In Art, Myth, and Science* (New York: Penguin Studio, 1997).

12 Marshall H. Kaplan, *Space Shuttle: America's Wings to the Future* (Fallbrook, CA: Aero Publishing, 1978); Lee Priestley, *America's Space Shuttle* (New York: J. Messner, 1978); Robert M. Powers, *Shuttle: The World's First Spaceship* (Harrisburg: Stackpole Books, 1979, 2d. ed., Warner Books, 1980); Kenneth W. Gatland, Mark Hewish, and Pearce Wright, *The Space Shuttle Handbook* (New York: Hamlyn, 1979); L.B. Taylor, Jr., *Space Shuttle* (New York: Thomas Crowell, 1979); Howard Allaway, *The Space Shuttle at Work* (Washington DC: National Aeronautics and Space Administration,

1979); Nigel Hawkes, *Space Shuttle* (New York: Gloucester Press, 1982, 2d. ed., 1989); Kerry Mark Joels and Greg Kennedy, *Space Shuttle Operator's Manual* (New York: Ballantine Books, 1982); Nigel MacKnight, *Shuttle* (Osceola, WI: Motorbooks International, 1985, 2d. ed., 1988); Tim Furniss, *Space Shuttle Log* (New York: Jane's, 1986); Andrew Wilson, *Space Shuttle Story* (New York: Hamlyn, 1986); H.R. Siepmann and D.J. Shayler, *From the Flightdeck 4: NASA Space Shuttle* (London: Ian Allen, Ltd., 1987); George Torres, *Space Shuttle: A Quantum Leap* (Novato, CA: Presidio Press, 1987, 2d. ed., 1989); Gene Gurney and Jeff Forte, *The Space Shuttle Log: The First 25 Flights* (Blue Ridge Summit, PA: Aero Books, 1988); George Forres, *Space Shuttle: The Quest Continues* (London: Ian Allen, 1989); Dennis R. Jenkins, *Rockwell International Space Shuttle* (Arlington: Aerofax Inc., 1989); and Bill Yenne, *Space Shuttle* (New York: Gallery Books, 1989).

13 Erik Bergaust, *Murder on Pad 34* (New York: G.P. Putnam's Sons, 1968).

14 Erland A. Kennan and Edmund H. Harvey, Jr., *Mission to the Moon: A Critical Examination of NASA and the Space Program* (New York: William Morrow and Co., 1969).

15 Malcolm McConnell, *Challenger: A Major Malfunction* (Garden City, NY: Doubleday and Co., 1987).

16 Joseph J. Trento and Susan B. Trento, *Prescription for Disaster: From the Glory of Apollo to the Betrayal of the Shuttle* (New York: Crown Publishers, 1987).

17 Hugh Young, Brian Silcock, and Peter Dunn, *Journey to Tranquillity: The History of Man's Assault on the Moon* (Garden City: Doubleday, 1970).

18 Gregg Easterbrook, "The Case Against NASA," *The New Republic* (8 July 1991): 18-24; Gene Koprowski, "Each Shuttle Flight: $1.67B," *Washington Technology* (26 September 1991); Alex Roland, "Barnstorming in Space: The Rise and Fall of the Romantic Era of Spaceflight, 1957-1986," in Radford Byerly, ed., *Space Policy Reconsidered* (Boulder: Westview Press, 1989); Alex Roland, "The Shuttle: Triumph or Turkey?" *Discover* (November 1985): 14-24; and T.A. Heppenheimer, "Lost in Space: What Went Wrong with NASA?" *American Heritage* 43 (July 1992): 60-72.

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Roland Barthes, "The Discourse of History," trans. Stephen Bann, *Comparative Criticism: A Yearbook* 3 (1981): 3-20.

20 Robert F. Berkhofer, Jr., "The Challenge of Poetics to (Normal) Historical Practice," *Poetics Today* 9 (1988): 435-52. For similar arguments see, F.R. Ankersmit, "Historiography and Postmodernism," *History and Theory* 28 (1989): 138-53; Sande Cohen, "Structuralism and the Writing of Intellectual History," *History and Theory* 17 (1978): 175-206; Dominick LaCapra, *Rethinking Intellectual History* (Ithaca: Cornell University Press, 1983); Hans Kellner, *Language and Historical Representation: Getting the Story Crooked* (Madison: University of Wisconsin Press, 1989); Stephen Bann, *The Inventions of History: Essays on the Representation of the Past* (Manchester: Manchester University Press, 1990); Brook Thomas, *The New Historicism: And Other Old-Fashioned Topics* (Princeton: Princeton University Press, 1991); and Hayden White, "The Fictions of Factual Representation," *Tropics of Discourse* (Baltimore: Johns Hopkins University Press, 1978): 121-34.

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22 Space does not allow a full discussion of all the quality books on space exploration history that have been published, even though the numbers produced have not been especially impressive.

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24 Rip Bulkeley, *The Sputnik Crisis and Early US Space Policy: A Critique of the Historiography of Space* (Bloomington: Indiana

University Press, 1991); David H. DeVorkin, *Science with a Vengeance: How the Military Created the US Space Sciences After World War II* (New York: Springer-Verlag, 1992); Robert A. Divine, *The Sputnik Challenge: Eisenhower's Response to the Soviet Satellite* (New York: Oxford University Press, 1993); Constance Green and Milton Lomask, *Vanguard: A History;* James J. Harford, *Korolev: How One Man Masterminded the Soviet Drive to Beat America to the Moon* (New York: John Wiley & Sons, 1997); Brian Harvey, *Race into Space: The Soviet Space Programme* (Chichester, England: Ellis Horwood Ltd., 1988); Alan J. Levine, *The Missile and Space Race* (New York: Praeger, 1994); Philip Nash, *The Other Missiles of October: Eisenhower, Kennedy, and the Jupiters, 1957-1963* (Chapel Hill: University of North Carolina Press, 1997); Jacob Neufeld, *Ballistic Missiles in the US Air Force, 1945-1960* (Washington DC: Center for Air Force History, 1990); Robert Reeves, *The Superpower Space Race: An Explosive Rivalry through the Solar System* (New York: Plenum Press, 1994); Peter J. Roman, *Eisenhower and the Missile Gap* (Ithaca: Cornell University Press, 1995); Paul B. Stares, *The Militarization of Space: US Policy, 1945-1984* (Ithaca: Cornell University Press, 1985); and Matthew J. Von Benke, *The Politics of Space: A History of US-Soviet/Russian Competition and Cooperation in Space* (Boulder: Westview Press, 1997).

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29 David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership* (Peterson Air Force Base, CO: Air Force Space Command, 1997).

30 Dwayne A. Day, “Not so Black and White...: the Military and the Hubble Space Telescope,” *Space Times: Magazine of the American Astronautical Society* 34 (March-April 1995): 20-21.

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CHAPTER 2. RATIONALES OF THE SPACE PROGRAM

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25 Smith, "Rough Stretches and Honest Disagreements," in *The Clinton Presidency,* 229. Also, see Craig A. Smith and Kathy B. Smith, *The White House Speaks: Presidential Leadership as Persuasion* (Westport: Praeger, 1994); Karlyn K. Campbell and Kathleen Hall Jamieson, *Deeds Done in Words: Presidential Rhetoric and the Genres of Governance* (Chicago: University of Chicago Press, 1990); and Roderick Hart, *Verbal Style and the Presidency: A Computer-Based Analysis* (New York: Academic Press, 1984).

26 Smith, "Rough Stretches and Honest Disagreements," in *The Clinton Presidency,* 229.

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29 Lyn Ragsdale, "Politics Not Science: The US Space Program in the Reagan and Bush Years," in *Spaceflight and the Myth of Presidential Leadership,* Roger D. Launius and Howard E. McCurdy eds. (Urbana: University of Illinois Press, 1997), 134.

30 James Vedda, "Evolution of Executive Branch Space Policy Making," *Space Policy* 12, no. 3 (1996): 178.

31 Launius and McCurdy, *Spaceflight and the Myth of Presidential Leadership,* 5.

32 In general, these descriptions of Presidential interest come from several sources including Presidential speeches and address, the essays included in Launius and McCurdy, *Spaceflight and the Myth of Presidential Leadership;* Linda T. Krug, *Presidential Perspectives on Space Exploration: Guiding Metaphors from Eisenhower to Bush* (Westport: Praeger, 1992); Vedda, "Evolution of Executive Branch Space Policy Making," *Space Policy* 12, no. 3 (1996); Roger Handberg et al., "The Myth of Presidential Attention to Space Policy," *Technology in Society* 17, no. 4 (1995): 337-348; Eugene Emme, "Presidents and Space, "in *Between Sputnik and the Shuttle: New Perspectives on American Astronauts,* (San Diego: American Astronautical Society, 1981): 5-138; John M. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (Cambridge: The MIT Press, 1970); and Carl Brauer, *Presidential Transitions: Eisenhower Through Reagan* (New York: Oxford University Press, 1986).

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37 John F. Kennedy, "News Conference," 12 April, 1961, *Public Papers of the Presidents of the United States, John F. Kennedy, 1961* (Washington DC: US Government Printing Office, 1962): 310.

38 Vaughn Davis Bornet, *The Presidency of Lyndon B. Johnson* (Lawrence: University of Kansas Press, 1983), 214.

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40 Lyndon B. Johnson, "News Conference," 20 March 1965, *Public Papers of the Presidents of the United States, Lyndon B. Johnson, 1965,* Vol. 1 (Washington DC: US Government Printing Office, 1966): 306.

41 Lyndon Johnson, "News Conference" (29 August 1965), 945.

42 Robert Dallek, "Johnson, Project Apollo, and the Politics of Space Program Planning," in Launius and McCurdy, *Spaceflight and the Myth of Presidential Leadership,* 80.

43 "Text of Address by Nixon in San Francisco Assessing Challenge of Soviet Satellite," *New York Times* (16 October 1957).

44 Joan Hoff, "The Presidency, Congress, and the Deceleration of the US Space Program," in the 1970s," in Launius and McCurdy, *Spaceflight and the Myth of Presidential Leadership,* 93.

45 Jules Witcover, *Marathon: The Pursuit of the Presidency 1972-1976* (New York: Viking, 1977), 35-45.

46 Emme, *Between Sputnik and the Shuttle,* 111.

47 Witcover, *Marathon,* 656.

48 Hoff, "The Presidency, Congress, and the Deceleration of the US Space Program," in *Spaceflight and the Myth of Presidential Leadership,* 106.

49 James E. Carter, "Remarks during a Telephone Call-In Program on the CBS Radio Network," 5 March 1977, *Public Papers of the President, James E. Carter, 1977,* Vol. I (Washington DC: US Government Printing Office, 1977): 48.

50 Howard E. McCurdy, *The Space Station Decision* (Baltimore: Johns Hopkins University Press, 1990), 41.

51 Ronald Reagan, "Remarks at the National Space Club Luncheon," March 29, 1985, *Public Papers of the President, Ronald Reagan, 1985,* Vol. I (Washington DC: US Government Printing Office, 1988), 365.

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57 Clinton, "Interview with Newspaper Editors," 1305.

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60 Logsdon, *Spaceflight and the Myth of Presidential Leadership,* 207.

61 Ibid. 209.

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63 Handberg et al, "The Myth of Presidential Attention to Space Policy," *Technology in Society* 17, no. 4, 338.

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65 Ibid. 345.

66 Ibid. 344.

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70 McCurdy, *Space and the American Imagination,* 243.

71 Krug, *Presidential Perspectives on Space.*

72 Tapes of President Kennedy discussion of the Moon landing idea with then NASA Administrator, James Webb, strongly supports this rethinking of Kennedy as a space visionary.

73 Handberg et al., "The Myth of Presidential Attention to Space Policy," *Technology in Society* 17, no. 4, 343.

74 Vedda, "Evolution of Executive Branch Space Policy Making," *Space Policy* 12, no. 3, 187.

75 Ragsdale, "Politics Not Science," in *Spaceflight and the Myth of Presidential Leadership,* 135.

76 Ibid. 135.

77 Dallek, "Johnson, Project Apollo, and the Politics of Space Program Planning," in *Spaceflight and the Myth of Presidential Leadership,* 80.

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80 W.D. Kay, *Can Democracies Fly in Space? The Challenge of Revitalizing the US Space Program* (Westport: Praeger, 1995).

81 The Landsat program is the world's first unclassified enterprise for the acquisition of imagery of the Earth from space. The first Landsat satellite was launched in 1972; the most recent satellite, Landsat 7, was launched on 15 April 1999. Landsat images, archived in the US and at receiving stations around the world, are a unique resource for global change research and applications in agriculture, geology, forestry, regional planning, education, and national security.

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84 Launius and McCurdy, "Epilogue: Beyond NASA Exceptionalism," in *Spaceflight and the Myth of Presidential Leadership,* 221-50.

CHAPTER 5. CONGRESS AND SPACE POLICY

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2 Bill Nelson, *Mission* (New York: Harcourt Brace Jovanovich, 1988), 32.

3 James Kerr, "Congress and Space: Overview or Oversight?" *Public Administration Review* 25, no. 3 (1965): 185; Thomas Jahnige, "The Congressional Committee System and the oversight Process: Congress and NASA," *Western Political Quarterly* 21, no. 2 (1968): 227; Thomas Murphy, "Congressional Liaison: The NASA Case," *Western Political Quarterly* (1972): 192; Nathan Goldman, *Space Policy* (Ames: Iowa State University Press, 1992), Chapter 5, 106-118; and Michael L. Telson, "NASA and the Budget Process," *Space Policy Alternatives,* (Boulder: Westview Press, 1994): 77-91.

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5 Roger Handberg, "Colliding With Political Reality: The Superconducting Super Collider, the Space Station, and National Science Policy: Congress, Constituency and Jobs," Paper presented at the Annual Meeting of the Southern Political Science Association, Tampa, November, 1995.

6 Quoted from *Aviation Week & Space Technology* 139(19 July 1993).

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10 Some people question the unbiased nature of either NSF or NRC also, as their findings are said to be influenced by the composition of the invited groups or committees which examine issues.

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(Washington DC: Government Printing Office, NASA History Series).

13 W.D. Kay, "Where No Nation Has Gone Before: Domestic Politics and the First International Space Science Mission," *Journal of Policy History* 5, no. 4 (Fall 1993); and Joan Johnson-Freese, "Canceling the US Solar Polar Spacecraft: Implications for International Cooperation in Space," *Space Policy* (February 1987).

14 Dwayne A. Day, "Doomed to Fail: The Birth and Death of the Space Exploration Initiative," *Spaceflight* 37, no. 3 (March 1995).

15 Roger Handberg, Joan Johnson-Freese, and Bill Nelson, "The Space Station, NASA and Congress: Micromanaging the Space Station," *Space Technology* 13, no. 6 (1993); and Hans Mark, *The Space Station, A Personal Journey,* (Durham: Duke University Press, 1987).

16 Walter A. McDougall, *...Heavens and the Earth: A Political History of the Space Age* (Baltimore: John Hopkins University Press, paperback edition, 1997).

17 W.D. Kay, *Can Democracies Fly in Space? The Challenge of Revitalizing the US Space Program* (Westport: Praeger, 1995).

18 Roger Launius, *NASA: A History of the US Civil Space Program,* (Malabar: Krieger Books, 1994) for a general history of the civil space program; and David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership* (Peterson Air Force Base: Air Force Space Command, 1997) for a history of Air Force space efforts.

19 The demise of the Superconducting Super Collider (SCC) is an example of a high-cost, high-tech program, which did not have the required support of numerous states, but rather only Texas, as it was to be located in Texas.

20 There have been occasional cases of individuals, such as Democratic Presidential candidate Michael Dukakis avidly and vocally speaking out against many aspects of the space program, and Republican allegations in 1998 that Clinton Administration policies regarding the launch of US technology on Chinese launch vehicles jeopardized national security.

21 President Clinton's Vice-President, Albert Gore, is, however, known to be a strong space advocate as well as a personal and professional supporter of Goldin.

22 William E. Burrows, "Why Build a Space Station?" *Popular Science* (May 1998): 67.

23 Craig Covault, "NASA, Defense Department Drop Idea of Private Shuttle Management," *Aviation Week & Space Technology* (29 April

1985): 42-44.

24 See, for example, Leroy N. Rieselbach, *Congressional Politics,* 2nd Edition (San Francisco: Westview Press, 1995); Malcolm E. Jewell and Samuel C. Patterson, *The Legislative Process in the United States,* 2nd Edition (New York: Random House, 1973); and Leroy N. Rieselbach, *Congressional Politics* (New York: McGraw Hill, 1973).

25 Berkeley, CA: University of California Press, 1967.

26 Quoted in Rieselbach, *Congressional Politics,* 1995: 389.

27 In earlier times it meant how much space activity could be brought to the district. The success of particular Members of Congress is often reflected by what space facilities are there today, witness, for example, Johnson Space Center in Houston, Texas.

28 Theresa M. Foley, "NASA centers shrink to survive leaner years," *Aerospace America* (March 1996): 34-39.

29 Ibid. 37.

30 Ibid. 34-29. Centers are still more protected than other locations. When the Clinton Administration in 1995 mandated big NASA work force cuts, NASA Headquarters in Washington bore the brunt of the hit. It was targeted to lose half its jobs by 1997. Politically, however, it is the easiest target and the cutback justifiable on the basis of removing layers of unnecessary bureaucracy.

31 Liz Lucci, "California Servicing Site to Add Extra Costs," *Space News* (2-8 May 1994): 10.

32 William Harwood, "NASA Aiming to Shift Shuttle Work to Florida," *Space News* (3-9 June 1996): 6.

33 Johnson-Freese and Handberg, *Space, the Dormant Frontier,* 134.

34 Nor are members of Congress by any means the only individuals whose jobs are influenced by pragmatism. For example, the needs of national defense are not always paramount behind each decision (from DOD's acquisition community). Other agendas quite often come into play, like careerism and the opportunity for well-paying jobs after retiring from the military. See James S. Burton, *Pentagon Wars,* (Annapolis: Naval Institute Press, 1993).

35 During the Bush Administration, Congress joined forces with NASA to decapitate a resurgent NSC, seeing it as becoming too powerful and upsetting the carefully established status-quo. The Clinton Administration opted not to staff the NSC, instead choosing to consolidate all space and technology development in the White House under the Science Advisor.

36 Roger Handberg, Joan Johnson-Freese, and Bill Nelson, "The Space

Station, NASA and Congress: Micromanaging Space Policy, *Space Technology* 14, no. 1 (1994): 4-5.

37 Irwin B. Arieff, "House Votes $16.1 Billion in Emergency Funds," *Congressional Quarterly Weekly Report* 38, no. 25 (21 June 1980).

38 Joan Johnson-Freese, "Canceling the US Solar Polar Spacecraft: Implications for International Cooperation in Space," *Space Policy* (February 1987): 24-37.

39 Joan Johnson-Freese and Roger Handberg, "Searching for Policy Coherence: The DOD Space Architect as an Experiment," *Joint Forces Quarterly* (Summer 1997).

40 John Jackson, "Statistical Models of Senate Roll Call Voting," *American Political Science Review* 65 (1971): 451-470; and David Kovenock, "Influence in the US House of Representatives," *American Politics Quarterly* 1 (1973): 407-464.

41 Douglas R. Arnold, *The Logic of Congressional Action* (New Haven: Yale University Press, 1990); Richard F. Fenno, *Home Style: House Members in Their Districts* (Boston: Little Brown, 1978); and Morris Fiorina, *Representatives, Roll Calls, and Constituencies* (Lexington: Lexington Books, 1974).

42 Aaron Wildavsky, *The New Politics of the Budgetary Process* (Glenview: Scott Foresman, 1988); and Aaron Wildavsky, *The New Politics of the Budgetary Process* (New York : Harper and Collins, 1992).

43 Robert A. Bernstein, *Congressional Voting Behavior: the Myth of Constituency Control* (Englewood Cliffs: Prentice Hall, 1989).

44 Defense policy is similar to space policy in that votes take place on complex and technical issues, such as arms development, which has distributive effects in the form of defense research and development contracts in a Congressional state or district. Energy and the environment are similar by virtue of their scientific nature, however, the analogy is limited in that environmental and energy issues also possess regulative policy dimensions. See Robert A. Bernstein and William W. Anthony, "The ABM Issue in the Senate, 1968-1970: The Importance of Ideology," *American Political Science Review* 68 (1974): 1198-1206; Robert A. Bernstein and Stephen R. Horn "Explaining House Voting on Energy Policy: Ideology and the Conditional Effects of Party and District Economic Interests," *Western Political Quarterly* 34, no. 2 (1981) 235-245; Michael L. Davis and Philip K. Porter, "A test for pure or apparent ideology in Congressional voting" *Public Choice* 60, no. 2 (1989): 101-111; Riley

E. Dunlap and Michael P. Allen, "Partisan Differences on Environmental Issues," *Western Political Quarterly* 29, no. 3 (1976): 384-397; Richard Fleisher, "Economic Benefit, Ideology, and Senate Voting on the B-1Bomber" *American Politics Quarterly* 13 (1985): 200-211; Wayne Moyer, "House Voting on Defense: An Ideological Explanation" in Bruce Russet and Alfred Stepan eds. *Military Force and American Society,* (New York: Harper and Row, 1973); Leonard G. Ritt and John M. Ostheimer, "Congressional Voting and Ecological Issues" *Environmental Affairs* 3, no. 3 (1974): 459-472; Jim Seroka and Andrew D. McNitt "Energy and Environmental Roll Call Voting in the US Congress in 1975 and 1979," *Policy Studies Review* 3 (1984): 406-416; Steven S. Smith, "The Consistency and Ideological Structure of the US Senate Voting Alignments, 1957-1976," *American Journal of Political Science* 25, no. 4 (1981): 780-795; and Frank Wayman, "Arms Control and Strategic Arms Voting in the Senate: Patterns of Change, 1967-1982," International Studies Association Meeting, Mexico City, Mexico, (5-9 April 1983).

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46 John W. Kingdon, *Congressman's Voting Decisions* (New York: Harper and Row, 1989).

47 Thomas Jahnige, "The Congressional Committee System and the Oversight Process: Congress and NASA," *Western Political Quarterly* 21 (1968): 227-239.

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51 Radford Byerly Jr., *Space policy Reconsidered* (Boulder: Westview

Press, 1989); Radford Byerly Jr., *Space Policy Alternatives* (Boulder: Westview Press, 1992); James L. Kauffman, *Selling Outer Space: Kennedy, the Media, and Funding for Project Apollo, 1961-1963* (Tuscaloosa: University of Alabama Press, 1994); Kay, *Can Democracies Fly in Space?*; John M. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (Cambridge: MIT Press, 1979); John M. Logsdon, "The Apollo Decision and Its Lessons for Policy Makers" *Program of Policy Studies in Science and Technology Occasional Paper* no. 7 (Washington DC: George Washington University, 1970); John M. Logsdon, "The Policy Process and Large Scale Space Efforts" *Space Humanization Series* (Institute for the Social Science Study of Space, 1979); John M. Logsdon, "The Decision to Develop the Space Shuttle" *Space policy* 2, (1986): 103-119; McCurdy, *The Space Station Decision*; and Robert W. Smith, *The Space Telescope: Politics, NASA, and Science* (Cambridge: Cambridge University Press, 1993).

52 Dwayne Day, "Doomed to Fail," *Spaceflight (*March 1995): 79-83.

CHAPTER 6. BUREAUCRACY AND THE SPACE PROGRAM

1 Howard E. McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice* (Baltimore: Johns Hopkins University Press, 1990), 40.

2 John M. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (*Cambridge:* MIT Press, 1970), 115.

3 Diane Vaughan, *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA* (Chicago: University of Chicago Press, 1996), 390.

4 Francis Hoban, *Where Do You Go After You've Been to the Moon? A Case Study of NASA's Pioneer Effort at Change* (Melbourne: Krieger Publishing Company, 1997), 77-185.

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6 Ibid. 101-105.

CHAPTER 7. PUBLIC ADMINISTRATION OF THE SPACE PROGRAM

1 For an overview of the contemporary visions of the American state and their inherent models of public administration, including the pre-state and pro-state orientations, see Richard J. Stillman, *Preface to Public Administration* (New York: St. Martins Press, 1991), Table 7.1, 173-218.

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3 For pro-state approaches see Leonard D. White, *The Federalists: A Study in Administrative History* (New York: MacMillan, 1948); Frederick W. Taylor, "Scientific Management," Testimony before the US House of Representatives (25 January 1912); and James L. Perry ed., *Handbook of Public Administration* (San Francisco: Jossey-Bass, 1989).

4 Stillman, *Preface to Public Administration,* 75-103.

5 Walter A. McDougall, *...The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985), 141-227.

6 For the importance of democratic responsiveness in the operation of American public administration of large-scale technology and the links between technology and society see James E. Webb, *Space Age Management* (New York: McGraw Hill Book Company, 1969); Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1970); W. Henry Lambright, *Governing Science and Technology* (Oxford: Oxford University Press, 1976); Malcolm Goggin ed., *Governing Science and Technology in a Democracy* (University of Tennessee Press, 1986); Matthew Evangelista, *Innovation and the Arms Race* (Ithaca: Cornell University Press, 1988); Michael E. Kraft and Norman J. Vig eds., *Technology and Politics* (Durham: Duke University Press, 1988); Francis Rourke, "Responsiveness and Neutral Competence in American Bureaucracy," *Public Administration Review* 52, no.6 (1992): 539-546; Stuart Hill, *Democratic Values and Technological Choices* (Stanford: Stanford University Press, 1992); and Edward Wenk, *Making Waves: Engineering, Politics, and the Social Management of Technology* (Chicago: University of Illinois Press, 1995).

7 "Heterogeneous engineering" is a concept, which recognizes that technological issues are simultaneously organizational, social,

economic, and political.

[8] McDougall, *...The Heavens and the Earth*; and Webb, *Space Age Management.*

[9] Barbara Romzek and Mel Dubnick, "Accountability in the Public Sector," *Public Administration Review* 47 (1987): 227-238.

[10] Carl J. Friedrich and Edward S. Mason eds., *Public Policy* (Cambridge: Harvard University Press, 1940), 3-14, 19-24.

[11] Stillman, *Preface to Public Administration,* 75-103.

[12] McDougall, *...The Heavens and the Earth,* 141-227.

[13] Compiled and developed by author, Eligar Sadeh.

[14] Thomas Jahnige, "The Congressional Committee System and the Oversight Process: Congress and NASA," *Western Political Quarterly* (1968): 227-239.

[15] James Kerr, "Congress and Space: Overview or Oversight?" *Public Administration Review* (1965): 185-192.

[16] Eligar Sadeh, "Politics of Space Policy: Congress and the US Civilian Space Program" (paper presented at the Western Political Science Association Annual Meeting, 14-16 March 1996, San Francisco, CA)

[17] Donald F. Kettl, *Sharing Power: Public Governance and Private Markets* (Brookings Institutions, 1993), 21-40.

[18] Ibid. 190-193.

[19] "Report of the Presidential Commission on the Space Shuttle Challenger Accident" (Washington DC: Government Printing Office, 1986), 164-177. Known hereafter as the Roger's Commission.

[20] Don K. Price has identified a number of estates or dimensions relative to the governance of science and technology. These include: (1) the scientific estate (scientists); (2) professional estate (technologists); (3) administrative estate (administrators); and (4) political estate (politicians and democratic values). These estates relate to the three dimensions of politics, administration, and technology identified in this study. See Price, *The Scientific Estate,* 132-136.

[21] For incremental models of decision-making see Charles E. Lindblom, "Still Muddling...Not Yet Through," *Public Administration Review* (November/December 1979): 517-526.

[22] David Collingridge, "Incremental Decision-Making in Technological Innovation," *Science, Technology, and Human Values* 14, no. 2 (1989): 141-162.

[23] Sadeh, "Politics of Space Policy."

[24] John M. Logsdon, "The Policy Process and Large Scale Space Efforts," *Space Humanization Series* (Washington DC: Institute for

the Social Science Study of Space, 1979): 65-79; Christopher Bellavita, "Public Policy, Organizational Theory, and Space Stations," *Policy Studies Review* 7 no. 2 (1987): 275-289; Adam L. Gruen, "The Port Unknown, NASA's Space Station" (Ph.D. diss. Durham: Duke University, 1989); and Howard E. McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice* (Baltimore: John Hopkins University Press, 1990).

25 Todd LaPorte and Paula Consolini, "Working in Practice but not in Theory: Challenges of High Reliability Organizations," *Journal of Public Administration Research and Theory* 1, no. 1 (1991): 19-48; and Martin Landau, "Redundancy, Rationality, and Problem of Duplication and Overlap," *Public Administration Review* 29 (1969): 346-358.

26 For NASA's major launch record from 1958 to 1994 see *NASA Pocket Statistics,* 1995 Edition (Washington DC: Government Printing Office). For example, in 1961 Atlas reliability was in the 60-70% range requiring extraordinary efforts to make it safe to launch humans.

27 Stephen B. Johnson, "Organizing the Manned Space Program," in Stephen B. Johnson, *The Secret of Apollo: R&D Management in American and European Space Programs* (Baltimore: Johns Hopkins University Press, 2002).

28 The decision for all-up testing of the Saturn V lunar launch vehicle was one of NASA's major administrative decisions during the 1960s. See Erasmus H. Kloman, "NASA Organization and Management from 1961 to 1965: The Vision and the Reality." in Francis T. Hoban ed., *Issues in NASA Program and Project Management* (NASA SP-6101(02), 1989):1-8.

29 Johnson, "Organizing the Manned Space Program."

30 Larry Heimann, "Understanding the Challenger Disaster: Organizational Structure and the Design of Reliable Systems," *American Political Science Review* 87 (1993): 421-435; and Larry Heimann, "Different Paths to Success: A Theory of Organizational Decision-Making and Administrative Reliability," *Journal of Public Administration Research and Theory* 5, no. 1 (1995): 45-71.

31 For overviews of the political, managerial, and technical factors related to the Apollo 204 fire see Senate Committee on Aeronautical and Space Sciences. *Apollo 204 Accident,* 90th Congress, 2nd Session, Senate Report 956 (Washington DC: US Government Printing Office, 1968); Arnold Levine, *Managing NASA in the Apollo*

Era (NASA SP-4102, 1982); and W. Henry Lambright, *Powering Apollo: James E. Webb of NASA* (Baltimore: Johns Hopkins University Press, 1995), 142-164.

32 Senate Committee on Aeronautical and Space Sciences, *Apollo 204 Accident.*

33 Heimann, "Understanding the Challenger Disaster."

34 The Report of the Apollo 204 Review Board (Washington: NASA, 1967) discounted managerial and political factors in the accident focusing exclusively on technical faults. For a critique of this assessment see Lambright, *Powering Apollo,* 142-164. In the case of the Challenger, the Roger's Commission, Vol. 1, 164-177 concluded that organizational and political variables contributed to the accident.

35 A case study of US administrative processes dealing with weapons innovation puts forward and substantiates this thesis that societal influences are more strongly felt in the US in the process of technological innovation. See Evangelista, *Innovation and the Arms Race,* Table 3, 52, 218-269.

Defense policy is similar to space policy in that it involves highly complex and technical issues such as arms development that has distributive effects on constituents in the form of defense research and development contracts in a Congressperson's state or district. Thus, the pressures for democratic representation are present.

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CHAPTER 14. INTERNATIONAL SPACE COOPERATION

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[25] Ibid. 48.

[26] Sebesta, *The Availability of American Launchers,* 1-32; and Roger M. Bonnet and Vittorio Manno, *International Cooperation in Space, The Example of the European Space Agency* (Cambridge: Harvard University Press, 1994), 75-81.

[27] Sebesta, *Politics of Technological Cooperation in Space,* 330.

[28] Ibid.

[29] Cooperation on the European Space Lab (ESL) led to an "Americanization," in terms of large-scale systems management and organizational techniques, of the European space effort. See Logsdon, "US-European Cooperation," 14; and Johnson, "Insuring the Future," 308.

[30] Madders, *A New Force at a New Frontier,* 457.

[31] The European Space Agency (ESA) was formed in 1975 on the basis of the European Space and Research Organization (ESRO); the European Launch and Development Organization (ELDO) was terminated in 1972. See John Krige and Arturo Russo, *Reflections on Europe in Space,* ESA HSR-11 (Noordwijk, The Netherlands: ESA Publications Division, January 1994).

[32] Madders, *A New Force at a New Frontier,* 444-476.

[33] NASA's space station program, which today is known as the International Space Station (ISS), was called Space Station Freedom from 1984 to 1992.

[34] Guiseppe Giampalmo, Head, International Relations, European Space Agency Headquarters, interview by author, Paris, France (17 October 1997).

[35] NASA described its plans for a Space Station program in 1984 to its prospective foreign partners as a "fully functional core space station" that the US will provide. This implied that NASA's part of the Station could function independently and could conceivably be built and operated without foreign participation or contributions. At that time, it was made clear that participation in NASA's core space station was excluded.

[36] Madders, *A New Force at a New Frontier,* 456.

[37] The planned polar platforms were dropped from the Space Station program in 1996. However, the planned Earth observation activities

that were to take place on the polar platforms continued on an independent basis.

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46 Michael Bourley, "The Legal Hazards of Transatlantic Cooperation in Space," *Space Policy* 6, no. 4 (1990): 323-331.

47 W.D. Kay, "Where No Nation Has Gone Before: Domestic Politics and the First International Space Science Mission," *Journal of Policy History 5,* no. 4 (1993): 437.

48 The European Space Agency also provided a probe for the International Solar Polar Mission in what was initially intended to be a two-probe mission.

49 Bourley, "The Legal Hazards," 323-331.

50 Kay, "Where No Nation Has Gone Before," 447-448.

51 For a discussion of the legal asymmetry that exists between the United States and European space programs, see Madders, *A New*

Force at a New Frontier, 448; and Bourley, "The Legal Hazards," 323-331.

Despite an asymmetry in the legal commitment to intergovernmental agreements and memoranda of understanding between NASA and the European Space Agency, there are a number of stable features. These features include assignment of relative technical responsibilities, designation of management structures, principles for operations, utilization and distribution of technical goods and data, liability and administrative assistance rules, dispute settlement procedures, and "no exchange of funds" with the caveat that obligations are subject to domestic authorization and availability of funds.

52 The European Space Agency programs in human spaceflight and Earth observations are optional.

53 Bonnet and Manno, *Example of the European Space Agency,* chapter 2.

54 Ibid. 98-108.

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56 Madders, *A New Force at a New Frontier,* 449-450.

57 Ibid.

58 John M. Logsdon, "US-Japanese Space Relations at a Crossroads," *Science* 255, no. 17 (1992): 297.

59 Joan Johnson-Freese, *Over the Pacific: Japanese Space Policy into the Twenty-First Century* (Dubuque: Kendall/Hunt Publishing, 1993); and Damon R. Wells and Daniel E. Hastings, "The US and Japanese Space Programs: A Comparative Study," *Space Policy* 7, no. 3 (1991): 239-240.

60 This policy was advocated by the Department of State but opposed by NASA and the Department of Defense. See Logsdon, "US-Japanese Space Relations," 297.

61 Logsdon, "US-Japanese Space Relations," 300; and Chikako Iguchi, "International Cooperation in Lunar and Space Development: Japan's Role," *Space Policy* 8, no. 3 (1992): 256-268.

62 Richard Barnes, interview by author. Also, see Matthew J. Von Bencke, *The Politics of Space: A History of US-Soviet/Russian Competition and Cooperation* (Boulder: Westview Press, 1997), 1-7.

63 Harvey and Ciccoritti, *US-Soviet Cooperation,* x.

64 Maxim Tarasenko, Research Associate, Moscow Institute of Physics and Technology, interview by author, Turin, Italy (9 October 1997); and Walter A. McDougall, ...*The Heavens and the Earth, A Political History of the Space Age* (Baltimore: Johns Hopkins University Press, paperback edition, 1997), 348-350.

65 Bencke, *The Politics of Space,* 193-194.

66 Frutkin, *International Cooperation,* 85-89.

67 Harvey and Ciccoritti, *US-Soviet Cooperation,* 92-103.

68 McDougall, *...The Heavens and the Earth,* 177-194.

69 Given the Soviet invasion of Afghanistan in 1979 and for other reasons, the 1977 United States-Soviet Intergovernmental Agreement on Space Cooperation was allowed to lapse without renewal in 1982.

70 Harvey and Ciccoritti, *US-Soviet Cooperation,* 230-236.

71 Apollo-Soyuz was widely praised as a symbol of détente. Its success led to follow-on discussions regarding possible cooperation between NASA's Space Shuttle program and Soviet Salyut space station program. This cooperative plan was suspended in 1979 amid a worsening of United States-Soviet relations and the collapse of détente in 1979-1980.

72 *US-Russian Cooperation in Space,* Office of Technology Assessment, United States Congress, OTA-ISS-618 (Washington DC: Government Printing Office, 1995), 43-46.

73 The "Mars Together '98" project envisioned a joint United States-Russian robotic orbiter/lander for the scientific study of Mars. This program was initially established in an "Implementing Agreement Between the National Aeronautics and Space Administration of the United States of America and the Russian Space Agency of the Russian Federation on NASA in the Russian Mars 94 Mission" in October of 1992 and through a report of a joint US/Russian technical working group in October of 1994. Despite the fact that the concept for "Mars Together '98" had clear scientific, technical, and financial benefits to both sides, it failed to materialize. Apparently, misunderstandings, misperceptions and miscommunication as to the technical and financial arrangements emerged. In the final analysis, cooperation failed not due to a lack of willingness among the scientists involved, but due to a failure to realize important functional preferences that each respective space agency possessed. Roger D. Bourke, "Mars Together '98" (presentation at a seminar on International Space Cooperation: Real World Examples, American Astronautical Society, Washington DC, 2 June 1998).

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75 For a more comprehensive account of expanded United States-Russian space cooperation since 1992, see Bencke, *The Politics of Space,* 99-108; and *US-Russian Cooperation in Space,* 46-48.

76 Bencke, *The Politics of Space,* 100.

77 "Agreement Among the Government of the United States of America, Governments of Member States of the European Space Agency, the Government of Japan, and the Government of Canada on Cooperation in the Detailed Design, Development, Operation and Utilization of the Permanently Manned Civil Space Station" (29 September 1988).

78 Harvey and Ciccoritti, *US-Soviet Cooperation,* 223-249.

79 Edward Ezell and Linda Ezell, *The Partnership: A History of the Apollo-Soyuz Test Project* (Washington DC: Government Printing Office 1978), Appendix D.

80 John M. Logsdon, "Together in Orbit: The Origins of International Participation in the Space Station," *Monographs in Aerospace History* 11 (Washington DC: NASA November 1998): 3-24.

81 Mission areas that were included in Space Station studies conducted by NASA and its potential foreign Partners encompassed: material science and space processing; life sciences; space sciences and applications; Earth observations; astronomical observations; and technology and operations. John D. Hodge, NASA "Space Station Program Description and Document," undated [1984].

82 *Public Papers of the Presidents of the United States: Ronald Reagan, 1984* (Washington DC: Government Printing Office, 1986), 90.

83 Madders, *A New Force at a New Frontier: Europe's Development in the Space Field,* 444-476.

84 "Memorandum of Understanding Between the United States National Aeronautics and Space Administration and the Government of Japan on Cooperation in the Detailed Design, Development, Operation and Utilization of the Permanently Manned Civil Space Station" (14 March 1989); "Agreement Among the Government of the United States of America, Governments of Member States of the European Space Agency, the Government of Japan, and the Government of Canada on Cooperation in the Detailed Design, Development, Operation and Utilization of the Permanently Manned Civil Space Station" (29 September 1988); "Memorandum of Understanding

Between the United States National Aeronautics and Space Administration and the European Space Agency on Cooperation in the Detailed Design, Development, Operation and Utilization of the Permanently Manned Civil Space Station" (29 September 1988); and Memorandum of Understanding Between the United States National Aeronautics and Space Administration and the Ministry of State for Science and Technology of Canada on Cooperation in the Detailed Design, Development, Operation and Utilization of the Permanently Manned Civil Space Station" (29 September 1988).

85 Canada was an important exception to this in that its robotic mobile servicing center for the Space Station is a critical path element in support of overall assembly and operations.

86 Howard E. McCurdy, *The Space Station Decision, Incremental Politics and Technological Choice* (Baltimore: Johns Hopkins University Press, 1990), 99-107 and 224-235.

87 NASA's policy preferences for cooperation as traditionally applied were not relevant. Cline and Gibbs, "Re-Negotiation;" and Cline, "International Negotiations."

88 Joan Johnson-Freese, *Changing Patterns of International Cooperation in Space* (Malabar: Orbit Book Company, 1990), 17-19; For a technical description of Intelsat operations, see Barbara Edelson, "Global Satellite Communications," *Scientific American* 236, no. 2 (1977): 58-73.

89 For an overview of negotiations and US space diplomacy, which led to Intelsat, see Joseph N. Pelton, *Global Communications Satellite Policy: Intelsat, Politics and Functionalism* (Mt. Airy: Lomond Books, 1974); and Jonathan F. Galloway, *The Politics and Technology of Satellite Communications* (Lexington: Lexington Books, 1972).

90 The American crusade– "space for the benefit of all mankind"– was an integral part of US space diplomacy during the Cold War. It served as "cloaked" diplomacy; the US put forward a visible and relatively open, in terms of science, civil space program to ensure "freedom of space" and to enable intelligence gathering on Soviet/Russia through space-based reconnaissance systems. See McDougall, *...Heavens and the Earth,* 344-360; and Cargill R. Hall, "Origins of US Space Policy: Eisenhower, Open Skies, and Freedom of Space," in *Exploring the Unknown, Volume I,* 213-229.

91 Joseph N. Pelton, "The History of Satellite Communications," in John M. Logsdon ed. *Exploring the Unknown, Selected Documents in the*

History of the US Civil Space Program, Volume III: Using Space, (Washington DC: Government Printing Office, 1998), 1-11.

92 For this idea as it relates to Intelsat, see Pelton, *Global Communications Satellite Policy.*

93 Edelson, "Global Satellite Communications," 58-73.

94 Intelsat is privately owned by an international group of over 200 shareholders; major owners include Lockheed Martin Global Telecommunications, Videsh Sanchar Nigam Ltd., France Telecom, Telenor Broadband Services A.S., and British Telecommunications pic. The US Open-market Reorganization for the Betterment of International Telecommunications Act ("ORBIT") calls for an initial public offering (IPO) of Intelsat shares.

95 Bencke, *The Politics of Space,* 40-78; and Glenn H. Reynolds and Robert P. Merges, *Outer Space: Problems of Law and Policy* (Boulder: Westview Press, second edition, 1997), 1-93.

96 Hall, "Origins of US Space Policy," 213-229.

97 Bencke, *The Politics of Space,* 48-62.

98 Reynolds and Merges, *Outer Space,* 48-49; and Harvey and Ciccoritti, *US-Soviet Cooperation,* 161-180.

99 "Treaty on Principles Governing the Activities of States in the Exploration and Uses of Outer Space, Including the Moon and Celestial Bodies," in Ian Brownlie ed., *Basic Documents in International Law* (New York: Oxford University Press, third edition, 1984): 204-211. For an insightful analyses of the "Outer Space Treaty," see Reynolds and Merges, *Outer Space,* 1-93; and Nathan C. Goldman, *American Space Law: International and Domestic* (San Diego: Univelt, second edition, 1996), 65-87.

100 These issues were intentionally left open ended in the 1967 Outer Space Treaty. Glenn H. Reynolds, "The Moon Treaty: Prospects for the Future," *Space Policy* 11, no. 2 (1995): 115-120.

101 Reynolds and Merges, *Outer Space,* 114-115.

102 European Space Agency (ESA) member states as of 1999 include Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and United Kingdom. Cooperative agreements have also been signed to allow Canada to participate in certain ESA programs and to sit on the ESA council.

103 The European Space Agency's scientific space projects from 1975 to the present have been within the policy guidelines of 20% cost capital limits (i.e., costs not to exceed the total budget of a project by more

than 20%).

104 The return coefficient allows for an equitable sharing of economic and industrial resources. For example, all member states had to have an 0.8 minimum return ratio from 1980 to 1985 with increases over time to 0.96 or better beginning in 1994.

105 The European Space Agency's Convention states that space application systems are optional. This implies that all member states participate except those that formally declare their intentions not to do so. This concept allows for states to match their level of financial involvement to industrial economic factors.

106 Joan Johnson-Freese, "A Model for Multinational Space Cooperation: The Interagency Consultative Group," *Space Policy* 9, no. 4 (1989): 288-300.

107 The Pathfinder concept involved positioning of the comet by Japanese and Soviet probes and NASA's deep space network to enable the European Space Agency's Giotto probe to encounter Halley's Comet nucleus within a range of 40 kilometers.

108 NASA was the only participating national space agency in the Interagency Consultative Group without a dedicated spacecraft to study Halley's comet.

109 The Interagency Consultative Group demonstrated that international cooperation on scientific objectives is feasible notwithstanding political, ideological and cultural barriers. Johnson-Freese, "A Model for Multinational Space Cooperation," 288-300.

110 Joan Johnson-Freese, "From Halley's Comet to Solar Terrestrial Science: The Evolution of the Interagency Consultative Group," *Space Policy* 12, no. 3 (1992): 245.

111 Freese, "From Halley's Comet," 254.

112 *Committee on Earth Observation Satellites Toward an Integrated Global Observing Strategy, 1997 Yearbook* (Surrey, England: Smith System Engineering Limited, 1997); and H. D. Hopkins et al., "Coordination of Earth Observation Activities through the Earth Observation International Coordinating Working Group" (paper presented at the 45th Congress of the International Astronautical Federation, 9-14 October 1994, Jerusalem, Israel).

113 Lisa R. Shaffer, "Coordination, Cooperation, Integration: Future Models for International Earth Observations" (paper presented at the 47th Congress of the International Astronautical Federation, Beijing, China, 7-11 October 1996); and Gregory S. Wilson and Wesley T. Huntress, "Mission to Planet Earth," *Palaeoclimatol, Global and*

Planetary Change Section 90 (1991): 317-328.

114 Ray Harris and Roman Krawec, "Some Current International and National Earth Observation Data Policies," *Space Policy* 9, no. 4 (1993): 273.

115 Gerald B Thomas, James P. Lester, and Willy Z. Sadeh, "International Cooperation in Remote Sensing for Global Change Research: Political and Economic Considerations," *Space Policy* 1, no. 2(1995): 131.

116 Harris and Krawec, "Some Current International and National Earth Observation Data Policies," 285.

117 Lisa R Shaffer, "International Cooperation in Earth Observation from Space," *Acta Astronautica* 22 (1990): 347-353.

118 The Committee on Earth Observation Satellites evolved out of scientific collaboration among national space agencies in Europe, France, India, Japan and the United States that took place through several Multilateral Meetings on Remote Sensing held in 1980 and 1982 and through Coordination on Land Observation Satellites and Coordination on Ocean Remote Sensing Satellites. "Minutes Committee on Earth Observations Satellites" (24-25 September 1984).

119 The membership of the Committee on Earth Observation Satellites (CEOS) includes national space agencies and space-based research organizations of Australia, Brazil, Canada, China, Europe, France, Germany, India, Italy, Japan, Russia, Sweden, Ukraine, United Kingdom and United States; Belgium, Canada, New Zealand and Norway are observers; and the Economic and Social Commission of Asia and Pacific, Food and Agricultural Organization, Global Climate Observing System, Global Ocean Observing System, Intergovernmental Oceanographic Commission, International Council of Scientific Unions, International Geosphere-Biosphere Program, United Nations Environmental Program, United Nations Office of Outer Space Affairs, World Climate Program and World Meteorological Organization are affiliates.

120 *Committee on Earth Observation Satellites Toward an Integrated Global Observing Strategy, 1997 Yearbook* (Surrey, England: Smith System Engineering Limited, 1997).

121 As part of this commitment to long-term global environmental research and monitoring, the Committee on Earth Observation Satellites, beginning in 1996, initiated an Integrated Global Observing Strategy (IGOS) aimed at coordinating missions and data policies for

all spaceborne and Earth-based observations of global environmental change.

122 Earth remote sensed data have the potential to engender sovereignty transparency and the "unbundling of territoriality." See John G. Ruggie, "Territoriality and Beyond: Problematizing Modernity in International Relations," *International Organization* 47, no. 1 (1993): 139-171; and Karen T. Litfin, *Ozone Discourses: Science and Politics in Global Environmental Cooperation* (New York: Columbia University Press, 1994).

123 The European Space Agency has put forward a dual mission strategy whereby one set of Earth observation missions, "Earth Explorer," emphasizes cooperation for Earth sciences, whereas, a second set of missions, "Earth Watch," accentuate Earth observation applications related to well identified user communities and commercial operational entities within Europe. Harald Arend, Earth Observation Strategy Manager, European Space Agency Headquarters, interview by author, Paris, France, October 16, 1997; and R. Bonnefoy and H. Arend, "ESA's Earth-Observation Strategy," *ESA Bulletin,* no. 85 (February 1996): 7-11.

124 Cooperation can take place when a particular state (or commercial entity) producing Earth observation data extends it to other states (e.g., open and free data transfer) or when knowledge diffusion is characterized as a collective good that is in joint supply. For a discussion of collective goods and international cooperation, see John G. Ruggie, "Collective Goods and Future International Cooperation," *American Political Science Review* 66, no. 3 (1972): 874-893.

125 Louis J. Levy and Susan B. Chadokewitz, "The Commercialization of Satellite Imagery," *Space Policy* 6, no. 3 (1990): 220.

126 Tom Crernins, "The New World Order, Global Change, and Space," *Acta Astronautica* 28 (1992): 327-334.

127 Jeffrey T. Richelson, "Scientists in Black," *Scientific American* 278, no. 2 (1998), 48-55.

128 Shaffer and Shaffer, "The Politics of International Cooperation."

129 Lynn Cline and Jeffrey Rosendahl, "An Assessment of Prospects for International Cooperation on the Space Exploration Initiative," *Acta Astronautica* 28 (1992): 391-399.

130 Eligar Sadeh, James P. Lester, and Willy Z. Sadeh, "Models of International Cooperation in Human Space Exploration for the Twenty-First Century," *Acta Astronautica* 34, no. 7-8 (1998): 427-435; and Eligar Sadeh, James P. Lester, and Willy Z. Sadeh,

"Modeling International Cooperation for Space Exploration," *Space Policy* 12, no. 3 (1996): 207-224.

131 For a broader discussion of how an interdependent-sovereign dynamic characterizes collaboration in science and technology, see John. G. Ruggie, "Collective Goods and Future International Collaboration," *American Political Science Review* 66 (1972): 874-893.

132 To date, NASA has never been directly involved in a cooperative program based on integration. Because of this fact, this particular chapter does not examine the integration outcome in detail.

133 Bencke, *Politics of Space,* 159-183.

134 Carl Sagan, *Pale Blue Dot* (New York: Random House, 1994), 215.

CHAPTER 15. COMPARATIVE SPACE POLICY

1 For the United States, see Pioneering the Space Frontier, Report of the National Commission on Space (New York: Bantam Books, 1986); Leadership and America's Future in Space, A Report to the NASA Administrator, by Sally K. Ride (Washington DC: Government Printing Office, August 1987); Report of the 90-Day Study on Human Exploration of the Moon and Mars, NASA Report Prepared for the NASA Administrator (Washington DC: NASA, 20 November 1989); Report of the Advisory Committee on the Future of the US Space Program, by Norman R. Augustine, chairman (Washington DC: Government Printing Office, 1990); and America at the Threshold: America's Space Exploration Initiative, Report of the Synthesis Group on America's Space Exploration Initiative, by Thomas P. Stafford, chairman (Washington DC: Government Printing Office, 1991). For Europe, see Bonnet, Roger M. and Vittorio Manno, International Cooperation in Space, The Example of the European Space Agency (Cambridge: Harvard University Press, 1994); Peter Creola, "ESA Ministerial Meeting: Consensus or Confrontation," *Space Policy* 7, no. 4 (1991); and Reiman Lust, "Where is Europe's Place in Space?" *Space Policy* 7, no. 4 (1991).

2 For such a view, see Howard McCurdy, *The Space Station Decision, Incremental Politics and Technological Choices* (Baltimore: Johns Hopkins University Press, 1990).

3 Letter from Nelson Rockefeller, Special Assistant to the President, to James Lay, Executive Secretary of the National Security Council (17

May 1955). This letter was attached as Annex E to the National Security Council, NSC 5520, "Draft Statement of Policy on US Scientific Satellite Program" (20 May 1955). See document in John M. Logsdon ed. *Exploring the Unknown, Selected Documents in the History of the US Civil Space Program, Volume I: Organizing for Exploration,* (Washington DC: Government Printing Office, NASA History Series, 1995): 308-313.

4 Robert A. Divine, *The Sputnik Challenge: Eisenhower's Response to the Soviet Satellite* (New York: Oxford University Press, 1993), 245.

5 This period is well documented and has been studied in a number of historical works. See for example, Divine, *The Sputnik Challenge;* Rip Bulkeley, *The Sputniks Crisis and Early US Space Policy* (Bloomington: Indiana University Press, 1991); and the documents collected in John M. Logsdon ed. *Exploring the Unknown, Volume I,* that pertain to the National Security Council internal debates on this issue.

6 "National Aeronautics and Space Act of 1958," Public-Law 85-568, in John M. Logsdon ed. *Exploring the Unknown, Volume I,* 334-345.

7 James E. Webb, NASA Administrator, and Robert S. McNamara, Secretary of Defense, to the Vice-President, 8 May 1961, with attached: "Recommendations for our National Space Program: Changes, Policies, Goals," in John M. Logsdon ed. *Exploring the Unknown, Volume I,* 445.

8 James C. Fletcher, "The Space Shuttle," in John M. Logsdon ed. *Exploring the Unknown, Volume I,* (22 November 1971): 555-556.

9 James A. Vedda, "Evolution of executive branch space policy-making," *Space Policy* 12, no. 3 (1996): 177-192.

10 *The Availability of American Launchers and Europe's Decision 'To Go It Alone'* (Noordwijk, The Netherlands: ESA Publications Division, September 1996), ESA HSR-18; and Lorenza Sebesta, "The Politics of Technological Cooperation in Space: US-European Negotiations on the Post-Apollo Program," *History and Technology* 11 (1994): 319-326.

11 Charles de Gaulle, French Radio, April 27, 1965.

12 Attributed to a high-level Belgian diplomat in 1970.

13 For more details, see ESA History Study Reports (HSR) especially, John Krige, *The Launch of ELDO* (Noordwijk, The Netherlands: ESA Publications Division, March 1993), ESA HSR-7; and Michelangelo De Maria, *The History of ELDO, Part 1: 1961-1964* (Noordwijk, The Netherlands: ESA Publications Division, September 1993), ESA

HSR-10.

14 Attributed to M. Bignier, first CNES General Director, in 1973.

15 For a detailed history of ESRO, see Arturo Russo, *ESRO's First Scientific Satellite Programme 1961-1966* (Noordwijk, The Netherlands: ESA Publications Division, October 1992), ESA HSR-2; and Arturo Russo, *The Definition of a Scientific Policy: ESRO's Satellite Programme in 1969-1973* (Noordwijk, The Netherlands: ESA Publications Division, March 1993), ESA HSR-6.

16 In 1975, the ESA Convention was signed by Belgium, Denmark, France, Germany, Ireland, Italy, The Netherlands, Spain, Sweden, Switzerland and the UK who were later joined by Norway, Austria, and Finland.

17 Article 2of the ESA Convention.

18 "Letter from Thomas Paine, NASA Administrator to A. Butterfield, Science Adviser to President Nixon, 22 November 1971." Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington DC.

19 The House of Representatives hearings held in December 1970 showed the importance attributed to manned spaceflight. In full agreement with NASA representatives, the principle aerospace firms argued for preserving human spaceflight projects as a jobs program. See *The National Space Program: Present and Future,* House of Representatives (10 December 1970), 61.

20 NASA Administrator James Fletcher, "Statement before the Senate Subcommittee on Space Science and Applications" (24 July 1980).

21 One solution that has been considered on the European space policy agenda is the creation of a high-level political organization, possibly modeled after the European Space Conference model or the European Union (EU).

22 *Report ofthe Advisory Committee,* 15-16.

23 Attributed to J. D. Levy, CNES Director General, in 1994.

24 Attributed to J. Broquet, Space Systems Engineering and Development Director at Marta Espace in France, 1991.

25 J. Broquet, 1991.

26 *Report ofthe 90 day Study.*

27 Attributed to J. D. Levy, CNES Director General, in 1994.

28 *A Post Cold War Assessment of US Space Policy, A Task Group Report,* Vice President's Advisory Board (December 1992), 14-15, 36 and 42.

29 According to a US Department State official interviewed by the

author, international cooperation is only viable for small projects. The official expressed that, if it [ISS] had to be done again, this program "wouldn't be repeated today." If "nobody believes that cooperation [with Russia] will save money" its [cooperation] use has rather appeared solely as one of diplomatic leverage. Today, far from reasserting the status of the space sector, leaving such a program [ISS] to be regulated by the hazards associated to any large scale international cooperation leads to question its fundamental political significance.

30 Attributed to J. D. Levy, CNES Director General, in 1997.

CHAPTER 16. SPACE AND THE MILITARY

1 For background on US plans for doomsday Moon bases see William E. Burrows, "Securing the High Ground *Air & Space Smithsonian* 8 (December 1993/January 1994): 64-69; Jeffrey T. Richelson, "Shootin' for the Moon," Bulletin of the Atomic Scientists (September/October 2000); and Lieutenant Colonel S. E. Singer, "The Military Potential of the Moon," *Air University Quarterly Review* 11 (Summer 1959): 31-53.

2 The best comprehensive work on the complex political maneuvering by the superpowers at the opening of the space age is Walter A. McDougall's *...the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985, rep. ed., Baltimore: Johns Hopkins University Press, 1997). The most extensive collection of primary source material on US military space efforts is the guide and microfiche documents in *US Military Uses of Space, 1945-1991: Guide and Index* (Washington and Alexandria, VA: Chadwyck-Healey, Inc., 1991). The best book-length treatment of US military space efforts during the Cold War with a focus on anti-satellite (ASAT) weapons is Paul B. Stares, *The Militarization of Space: US Policy, 1945-1984* (Ithaca: Cornell University Press, 1985). The Air Force has recently published four welcome additions to the literature on military space: Curtis Peebles, *High Frontier: The US Air Force and the Military Space Program* (Washington D.C.: Air Force History and Museums Program, 1997); David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership* (Peterson AFB: Air Force Space Command, 1997); R. Cargill Hall and Jacob Neufeld, eds., *The US Air Force in Space: 1945 to the 21st Century*

(Washington D.C.: Air Force History and Museums Program, 1998); and James E. Oberg, *Space Power Theory* (Washington D.C.: GPO, March 1999). Finally, there are three outstanding recent additions to military space literature: Barry D. Watts, "The Military Use of Space: A Diagnostic Assessment," (Washington D.C.: Center for Strategic and Budgetary Assessments, February 2001); Steven Lambakis, *On the Edge of Earth: The Future of American Space Power* (Lexington: University Press of Kentucky, 2001); and Everett C. Dolman, *Astropolitik: Classic Geopolitics in the Space Age* (London: Frank Cass, 2001).

3 Then Air Force Chief of Staff, General Merill A. McPeak gave this label to the Gulf War. His quote is reprinted in Major Michael J. Muolo, *Space Handbook: A Warfighter's Guide to Space* (Maxwell AFB, AL: Air University Press, December 1993).

4 This chapter focuses on US Space Command's (USSPACECOM) 1998 report entitled *Long Range Plan: Implementing USSPACECOM Visionfor 2020* (Peterson AFB, CO: US Space Command, Director of Plans, March 1998). The *Long Range Plan* is the most comprehensive vision for US military space ever produced and warrants close scrutiny.

5 Many US Government documents list three rather than four space sectors. Upon closer examination, however, these documents reveal the important contributions of each of the four sectors discussed above. For example, the most recent National Space Policy discusses civil, national security (defense and intelligence), and commercial sectors. National Science and Technology Council, "Fact Sheet: National Space Policy" (Washington D.C.: The White House, 19 September 1996). The term "space sectors" was first used as an organizing typology in President Jimmy Carter's 1978 National Space Policy. National Security Council, "Presidential Directive/NSC-37: National Space Policy" (Washington D.C.: The White House, 11 May 1978).

6 *Report of the Commission to Assess National Security Space Management and Organization* (Washington D.C.: Commission to Assess National Security Space Management and Organization, 11 January 2001), 10-14, (hereinafter Space Commission Report).

7 *Long Range Plan,* 19-20. The Air Force replaced the term "space control" with the term "counterspace" in the 2001 version of Air Force Doctrine Document (AFDD) 2-2 *Space Operations:*

Counterspace operations consist of those operations conducted to attain and maintain a desired degree of space superiority by allowing friendly forces to exploit space capabilities while negating an adversary's ability to do the same. Counterspace operations include two elements, offensive and defensive counterspace, both predicated on space surveillance and other intelligence. Air, space, land, sea, information, or special operations can perform counterspace functions.

Offensive counterspace (OCS) operations preclude an adversary from exploiting space to his advantage. Should policy allow, OCS actions may target an adversary's space system, forces, and information links, or third-party space capabilities supporting those forces, using lethal or nonlethal means. Possible methods include the use of deception, disruption, denial, degradation, and destruction of space capabilities. The "Five Ds" represent a continuum of options, from spoofing the enemy to hard-kill of a space asset. However, there are tradeoffs along the continuum. At the destruction end of the continuum, airmen can be confident that an adversary's space asset and the effect it produced have been eliminated. However, there may be undesirable collateral effects, such as added debris threats in orbit, or negative world opinion. At the deception end of the continuum, airmen may have less confidence in achieving the desired effect, but have more confidence in not producing any adverse collateral effects.

> Deception employs manipulation, distortion, or falsification of information to induce adversaries to react in a manner contrary to their interests.
> Disruption is the temporary impairment of some or all of a space system's capability to produce effects, usually without physical damage.
> Denial is the temporary elimination of some or all of a space system's capability to produce effects, usually without physical damage.
> Degradation is the permanent impairment of some or all of a space system's capability to produce effects, usually with physical damage.
> Destruction is the permanent elimination of all of a space system's capabilities to produce effects, usually with physical damage.

Assets designed for the OCS mission may be used to conduct or support counterair, countersea, counterland, counterinformation, or strategic attack missions by performing offensive counterspace actions where the adversary's vulnerable node is a space system.

Defensive counterspace (DCS) operations preserve US/allied ability to exploit space to its advantage via active and passive actions to protect friendly space-related capabilities from enemy attack or interference. Although focused on responding to man-made hostile intent, DCS actions may also safeguard assets from unintentional hazards such as space debris, RF interference, and other natural occurring events. Defensive counterinformation (DCI) operations and force protection measures may be employed in support of DCS. Active defense seeks to detect, track, identify, characterize, intercept, or negate adversary threats and unintentional hazards to friendly space capabilities. Passive defense seeks to ensure the survivability of friendly space assets, and the information they provide.

Space situational awareness (SSA) forms the foundation for all counterspace and other space actions. It includes traditional space surveillance, detailed reconnaissance of specific space assets, collection and processing of space intelligence data, and analysis of the space environment. It also encompasses the use of traditional intelligence sources to provide insight into adversary space operations. Air Force Doctrine Document 2-2 *Space Operations* (Maxwell AFB: Air Force Doctrine Center, 27 November 2001), 9-10.

8 Lt Col David E. Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB: Air University Press, June 1988).

9 NSC-5520 was signed on 20 May 1955 and is reprinted in John M. Logsdon ed. *Exploring the Unknown: Selected Documents in the History of the US Civil Space Program, Volume I,* (Washington D.C.: NASA History Office, 1995), 308-313. McDougall in *...the Heavens and Earth* and R. Cargill Hall's introductory essay, "Origins of US Space Policy: Eisenhower, Open Skies, and Freedom of Space," in Logsdon ed. *Exploring the Unknown, Volume I,* do an excellent job in developing the context and purposes for which NSC-5520 was developed.

10 Hall uses the term stalking horse to describe the purpose of the IGY satellite in relation to the WS-117L (America's first spy satellite program). For the most complete analysis of the IGY program see

Rip Bulkeley, *The Sputniks Crisis and Early United States Space Policy: A Critique of the Historiography of Space* (Bloomington: Indiana University Press, 1991).

11 *US Military Uses of Space,* Chronology. Dyna-Soar was redesignated as the X-20 from June 1962 until the program was cancelled in December 1963. For the most comprehensive analysis of the Dyna-Soar program, see Roy Franklin Houchin, II, "The Rise and Fall of Dyna-Soar: A History of Air Force Hypersonic Research and Development, 1944-1963" (Ph.D. diss., Auburn University, 1995).

12 In a recent example of military space programs being cancelled due to political concerns, the Clinton Administration made its first use of the line item veto in a November 1997 defense spending bill by cutting the military space plane, the kinetic-kill ASAT, and the Clementine II asteroid probe. The Supreme Court subsequently (June 1998) struck down the line item veto as unconstitutional.

13 See Spires, *Beyond Horizons* and Peebles, *High Frontier* on the military space system incremental improvements highlighted by the Gulf War.

14 For estimates on commercial space revenues see Vice President's Space Policy Advisory Board Task Group Report, "The Future of the US Space Industrial Base," (Washington DC: Vice President's Space Policy Advisory Board Task Group, November 1992); The Futron Corporation, Satellite Industry Guide (Bethesda: Futron Corporation, October 1999); and Space Commission Report, 11. On 31 July 2001 the Acting Assistant Secretary of Defense for Command, Control, Communications, and Intelligence testified before Congress that the more than 120 satellites DOD controls using the 1755-1850 MHz band represent a cumulative investment of about $100 billion. United States General Accounting Office, "Defense Spectrum Management: More Analysis Needed to Support Spectrum Use Decisions for the 1755-1850 MHz Band," (Washington D.C.: General Accounting Office, August 2001).

The critical importance of the burgeoning commercial space sector to any overarching US space strategy is a major theme in three excellent recent articles: Frank G. Klotz, *Space, Commerce, and National Security* (New York: Council on Foreign Relations Press, 1998); General Thomas S. Moorman, Jr., "The Explosion of Commercial Space and the Implications for National Security," *Airpower Journal* 13, no. 1 (Spring 1999): 6-20; and John M. Logsdon and Russell J. Acker, eds., *Merchants and Guardians:*

Balancing US Interests in Global Space Commerce (Washington D.C.: Space Policy Institute, George Washington University, May 1999).

15 For a more complete listing of all the US organizations involved in setting space policy see Frank G. Klotz, *Space, Commerce, and National Security* (New York: Council on Foreign Relations Press, 1998).

16 Office of the Joint Chiefs of Staff, "Chronology of Changes in Key West Agreements, April 1948-January 1958," Washington DC: Joint Chiefs of Staff Historical Section, February 7, 1958. The best analysis of Army-Air Force rivalry over developing intermediate-range ballistic missiles during the 1950s is Michael H. Armacost, *The Politics of Weapons Innovation: The Thor-Jupiter Controversy* (New York: Columbia University Press, 1969).

17 Peter L. Hays, "Struggling Towards Space Doctrine: US Military Plans, Programs, and Perspectives During the Cold War" (Ph.D. diss., Fletcher School of Law and Diplomacy, Tufts University, 1994): 161-172.

18 Hays, "Struggling Towards Space Doctrine," 169. DOD Directive 5160.32 is reprinted in John M. Logsdon ed. *Exploring the Unknown, Volume 2,* (Washington DC: Government Printing Office, 1996), 314-315.

19 The key player during this period was the Director of Defense Research and Engineering (DDR&E), Herbert F. York. York explains his decisions in *Race to Oblivion: A Participant's View of the Arms Race* (New York: Simon & Schuster, 1970).

20 The first DOD Space Policy was dated 10 March 1987. The new DOD Space Policy is Department of Defense Directive 3100.10 (Washington DC: Department of Defense, 9 July 1999).

21 For an analysis of the bureaucratic politics environment facing the Space Architect see Joan Johnson-Freese and Roger Handberg, "Searching for Policy Coherence: The DOD Space Architect as an Experiment," *Joint Force Quarterly* 16 (Summer 1997): 91-96.

22 For strident positions on what the Navy's role in space should be see Commanders Randall G. Bowdish and Bruce Woodyard, USN, "A Naval Concepts Based Vision for Space," and Commander Sam J. Tangredi, USN, "Space Is an Ocean," *US Naval Institute Proceedings* 125 (January 1999): 50-53.

23 The most comprehensive work on von Braun's programs in both Germany and the United States is Frederick I. Ordway and Mitchell

R. Sharpe, *The Rocket Team* (New York: Thomas Y. Crowell, 1979). For more in-depth analysis of von Braun's efforts in Germany, see Michael J. Neufeld, *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era* (New York: Free Press, 1995).

24 George Kistiakowsky, *A Scientist at the White House: The Private Diary of President Eisenhower's Special Assistant for Science and Technology* (Cambridge: Harvard University Press, 1976) provides a first-hand account from one of the principals involved in creating the NRO. For additional analysis on the political factors leading to the creation of the NRO see William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Berkley Books, 1986); Jeffrey T. Richelson, *America's Secret Eyes in Space: The US Keyhole Spy Satellite Program* (New York: Harper & Row, 1990); and Dwayne A. Day, John M. Logsdon, and Brian Latell, *Eye in the Sky: The Story of the Spy Satellites* (Washington DC: Smithsonian Institution, 1998). On the 1992 declassification of the NRO see Bill Gertz, "The Secret Mission of NRO," *Air Force Magazine* 76 (June 1993): 60-63.

25 The Office of Missile and Satellite Systems within the Office of the Secretary of the Air Force was established on 31 August 1960 as the "cover" organization for the NRO. The NRO itself was formally established on 6 September 1961. See Richelson, *America's Secret Eyes,* 46-47; and one of the first official explanations of the NRO's roots by NRO historian, Gerald Haines, "The National Reconnaissance Office: Its Origins, Creation, and Early Years," in Day, *Eye in the Sky,* 143-156.

26 On the subtle but pervasive links between NTM and the political process of verification see Robert Joseph DeSutter, "Arms Control Verification: 'Bridge' Theories and the Politics of Expediency" (Ph.D. diss. University of Southern California, 1983).

27 Not surprisingly, the NRO's starring role in shaping these space policy developments is not well documented. On the political factors influencing STS design and the rationale behind its 60 by 15 feet cargo bay see John M. Logsdon, "The Decision to Develop the Space Shuttle," *Space Policy* 2 (May 1986): 103-119. Former Secretary of the Air Force (and NRO Director) Edward ("Pete") Aldridge vented his frustrations with NASA in struggling to develop the Complementary Expendable Launch Vehicle (CELV) and take some spysats off the STS in "Assured Access: 'The Bureaucratic Space War,' Dr. Robert H. Goddard Historical Essay, Office of the

Secretary of the Air Force. The CELV evolved into the *Titan IV*.

28 Construction of the NRO's consolidated headquarters generated a considerable amount of public scrutiny during the period of 1994-96 because it was contemporaneous with revelations that the NRO had accumulated a "slush fund" of some $4 billion in unspent funding. In the ensuing political fallout, both NRO Director Jeffrey K. Harris and Deputy Director Jimmie D. Hill ended up losing their jobs. The need to reorient and perhaps reorganize the Intelligence Community (IC) in order to deal more effectively with changed objectives and missions in the post-Cold War world is a central theme of many recent analyses. See, for example, Bruce D. Berkowitz and Allan Goodman, *Best Truth: Intelligence and Security in the Information Age* (New Haven: Yale University Press, 1999). The last recent official USG study on these issues, however, argued against making any sweeping changes in current IC organization or missions; see *Preparing for the 21st Century: An Appraisal of US Intelligence* (Washington DC: Commission on the Roles and Capabilities of the United States Intelligence Community, 1 March 1996). In May 2001, under National Security Presidential Directive (NSPD)-5, President Bush ordered a comprehensive review of US intelligence capabilities to be conducted by both internal and external panels. See Vernon Loeb, "US Intelligence Efforts to Get Major Review," *Washington Post* (12 May 2001): 3. In the wake of the 11 September 2001 terrorist attacks it seems likely there will be renewed calls to reorient and reorganize the IC that go beyond just the creation of the new Office of Homeland Security.

29 Lieutenant Colonel (retired) Frank W. Jennings, "Doctrinal Conflict Over the Word Aerospace," *Airpower Journal* 4 (Fall 1990): 46-58. It is important to note that DOD and the other Services have never accepted the Air Force's aerospace concept.

30 According to the Air Force's formulation of the aerospace concept in AFDD 2-2 *Space Operations:* "The aerospace medium can be most fully exploited when considered as a whole. Although there are physical differences between the atmosphere and space, there is no absolute boundary between them. The same basic military activities can be performed in each, albeit with different platforms and methods. Therefore, space operations are an integral part of aerospace power." Space power is the capability to employ space forces to achieve national security objectives. Used effectively, space power enhances America's chances to succeed across the broad range

of military operations. Space power is derived from the exploitation of the space environment by a variety of space systems. A key element of space power is the people who operate, maintain, or support these systems. Space affords a commanding view of operations and provides an important military advantage. At the level of basic aerospace doctrine, the principles that govern aerospace operations are the same for air and space." (emphasis in original.) AFDD 2-2 *Space Operations,* 1. For an interesting perspective on the aerospace concept that argues that its roots are explicitly linked to airpower theory and are easily traced to General Hap Arnold's 1944 vision of the Air Force's future. Major Stephen M. Rothstein, "Dead on Arrival? The Development of the Aerospace Concept, 1944-1958" (Masters Thesis, School of Advanced Airpower Studies, June 1999).

31 The cancellation of MOL is particularly telling since this indicated the Air Force could not get approval for military personnel in space even to conduct highest priority intelligence-gathering activities.

32 Brigadier General (retired) Earl S. Van Inwegen, "The Air Force Develops an Operational Organization for Space," in Hall and Neufeld, *The Air Force in Space,* 134-143.

33 The Air Force "fields the majority of...space capabilities within the Department of Defense." The Air Force contributes 90 percent of the personnel; 85 percent of the space budget, 86 percent of space assets, and 90 percent of space infrastructure. See General Michael E. Ryan and the Honorable F. Whitten Peters, *The Aerospace Force: Defending America in the 21st Century: A White Paper on Aerospace Integration* (Washington DC: Department of the Air Force, May 2000), 5

34 In May 2002 General Eberhart was nominated to become the first Commander of the new North American Command, which is primarily responsible for American homeland defense. In addition, in October 2002 USSPACECOM and United States Strategic Command were merged together into a single command headquartered at Offutt AFB, NE.

35 Robert S. Dudney, "Washington Watch: The New Space Plan," *Air Force Magazine* 81, no. 7 (July 1998).

36 Dudney, "Washington Watch."

37 General Howell M. Estes, III, "The Promise of Space Potential for the Future," prepared remarks to the United States Space Foundation's 1997 National Space Symposium, Colorado Springs, 3 April 1997.

38 *Long Range Plan,* 4-5, 33.

39 The idea that the "flag follows trade" is from Klotz, *Space, Commerce, and National Security,* 15-20.

40 General Ronald R. Fogleman and the Honorable Sheila E. Widnall, *Global Engagement: A Vision for the 21st Century Air Force* (Washington DC: November 1996), 8. Emphasis in original.

41 Klotz, *Space, Commerce, and National Security,* 55; and Lt Col Paul L. Bailey, "Space as an Area of Responsibility," *Air Chronicles* (Winter 1998).

42 General Richard B. Myers, "Integrating Space in an Uncertain Era," prepared remarks to the Air Force Association Space Symposium, Los Angeles, 13 November 1998.

43 Quoted in Peter Grier, "The Investment in Space," *Air Force Magazine* 83, no. 2 (February 2000).

44 Gen. Richard B. Myers, "Space Superiority Is Fleeting," *Aviation Week & Space Technology* 152, no.1 (1 January 2000): 54-55

45 General Michael E. Ryan and the Honorable F. Whitten Peters, *Global Vigilance, Reach & Power: America's Air Force Vision 2020* (Washington DC: Department of the Air Force, June 2000).

46 Air Force Chief of Staff General Merill McPeak moved away from the aerospace concept in June 1992 by changing the Air Force mission statement by adding the words "air and space." The Air Force recognizes that there are physical differences between the atmosphere and space but defines aerospace as a seamless operational medium comprised of both physical domains. See Air Force Doctrine Document 22 *Space Operations* (Maxwell AFB: Air Force Doctrine Center, 23 August 1998), 1. For a critique of the aerospace concept see Lt Col Peter Hays and Dr. Karl Mueller, "Going Boldly – Where? Aerospace Integration, the Space Commission, and the Air Force's Vision for Space," *Aerospace Power Journal* 15, no. 1 (Spring 2001): 34-49

47 For the period of General Ryan's tenure as Chief of Staff of the Air Force (Oct. 1997-Sep. 2001), the Air Force emphasized that there are physical differences between the atmosphere and space but defined aerospace as a seamless operational medium comprised of both physical domains. See, for example, Air Force Doctrine Document 2-2 *Space Operations.* (Maxwell AFB, Ala.: Air Force Doctrine Center, 23 August 1998), 1 or *Global Vigilance, Reach & Power.* As reflected in recent speeches and the 27 November 2001 edition of AFDD 2-2, General John P. Jumper, the current USAF Chief of Staff,

has chosen to return to using "air" and "space" as separate words rather than continuing to use the term "aerospace."

> Let me start off by talking a little bit about air and space versus aerospace. I carefully read the Space Commission report. I didn't see one time in that report, in its many pages, where the term "aerospace" was used. The reason is that it fails to give the proper respect to the culture and to the physical differences that abide between the physical environment of air and the physical environment of space.
>
> We need to make sure we respect those differences. So, I will talk about air and space. I will respect the fact that space is its own culture, that space has its own principles that have to be respected. And when we talk about operating in different ways in air and space, we have to also pay great attention to combining the effects of air and space because in the combining of those effects, we will leverage this technology we have that creates the asymmetrical advantage for our commanders.

Prepared Remarks of General John P. Jumper at Air Force Association National Symposium, Los Angeles, CA, 16 November 2001.

48 General Eberhart did not put much emphasis on commercial space developments and did not even mention the term COG in his 8 March 2000 testimony to the Senate Armed Services Committee Strategic Subcommittee; or in his 4 April 2000 keynote speech to the United States Space Symposium. USSPACECOM picked up the CND mission in 1999 and became responsible for CNA on 1 October 2000. It is not yet clear how the command will organize to perform these new missions; one proposal is for a unified subcommand. See George I. Seffers, "Cyberwar Ops May Unify," *Federal Computer Week* (30 October 2000): 12.

49 John A. Tirpak, "The Fight for Space," *Air Force Magazine* 83, no. 8 (August 2000).

50 Quoted in William B. Scott, "Cincspace: Focus More on Space Control," *Aviation Week & Space Technology* (15 November 2000).

51 Futron Corporation, *Satellite Industry Guide* (Bethesda: Futron Corporation, October 1999). Futron's guide, based on their proprietary database and published in partnership with the Satellite Industry Association and George Washington University's Space

Policy Institute, uses a "consistent and reliable set of industry metrics based on primary research data" to provide a comprehensive survey of where the industry has been and where it is heading.

52 Aerospace corporations form an important part of the US economy but in pure dollar terms they are simply not a dominant sector or an economic COG in terms of overall value, revenues, or market capitalization. Futron reports that global commercial space activities generated a total of $69 billion in revenues in 1999, and while this is clearly a lot of money in absolute terms, it represents only 8.7 percent of the revenues of just the top five US corporations (General Motors, Wal-Mart, Exxon Mobil, Ford, and General Electric) from the *Fortune* 500 list for 2000. But, how about the market valuation of space corporations? At the end of 1999 the combined market valuation for all major US aerospace firms (Boeing, Honeywell, United Technologies, General Dynamics, Textron, Lockheed Martin, Raytheon, TRW, Northrop Grumman, and Litton Industries) amounted to approximately $150 billion but was still less than the market valuation of Home Depot Corporation.

The intent of these comparisons is not to depreciate the importance of commercial space activities; rather, they are designed to show that commercial space activities do not yet constitute a COG for the economies of the United States or the world. The comparisons also help to illuminate the true strategic utility of commercial space activities and highlight that these activities should be thought about and valued in a variety of ways other than just in terms of economics.

53 Despite the relatively small size of commercial space in comparison with the whole US economy, it is nonetheless a vibrant sector that is growing very rapidly and creating novel commercial activities. A few statistics and trends assessed by Futron Corporation illustrate the overall state of the commercial space sector. During the period from 1996 through 2000, for example, global commercial space revenues rose 85 percent, going from $44.8 billion to $83 billion; and total employment rose 46 percent, from 173,400 to 253,600. Likewise, from 1996 to 1998 the total number of satellites launched each year (both commercial and non-commercial) rocketed up 80 percent from 86 to 155. See Phil McAlister, "1999 Year in Review," Futron Corporation Slide Presentation to Office of Net Assessment, the Pentagon, 21 November 2000). In retrospect, however, 1998 represents a spike in launch numbers that was clearly caused by a major push to populate big non-geostationary orbit (big non-

geostationary systems) constellations such as Iridium and Globalstar with relatively small-networked comsats. It is unclear whether this pattern will be repeated due to the cloudy prospects for future big non-geostationary systems and the larger number of satellites that may be carried per launch on future systems.

A primary factor driving the actual number of new satellites launched will be the long-term commercial viability of the big non-geostationary communications systems such as Iridium and Teledesic. Motorola's Iridium system, a 66-satellite network that provides global cellular phone services, became the first operational big non-geostationary systems in September 1998, declared bankruptcy August 1999, and was rescued by DOD's Defense Systems Information Agency (DISA) in December 2000. ICO-Teledesic Global– a joint venture between telecommunications pioneer Craig McCaw, Microsoft Chairman Bill Gates, and others that is estimated to cost more than $9 billion to develop– is a 288-satellite system designed to provide "fiber-like" (up to 64 million bits per second) global telecommunications services such as broadband Internet access, video conferencing, and interactive multimedia that is now scheduled to become operational in 2005. These big non-geostationary systems hold the potential to change how millions of users receive pager, cellular phone, and Internet services and thereby to transform the telecommunications industry worldwide. At present, however, it is not clear that they can be developed cheaply, quickly, and flexibly enough to compete effectively with terrestrial alternatives for most applications.

54 At least partially as a result of the Cox Report, in March 1999 Hughes Space and Communications Company was denied an export license to deliver two satellites to the Singapore-based Asia Pacific Mobile Telecommunications (APMT) Consortium because the satellites were scheduled to be launched on Chinese Long March ELVs and because it was alleged that the People's Liberation Army held a controlling interest in APMT. See, for example, Warren Ferster and Sam Silverstein, "Hughes Picks Up Pieces," *Space News* (8 March 1999): 1 and 19.

NASA normally emphasizes Russian expertise in space station operation and long-duration spaceflight as the primary rationale for the 1993 US decision to bring the Russian Federation aboard as a full partner on the ISS program. The genesis and rationale for this decision, however, can also be seen as the product of

high politics combined with a specific US interest in using Russian participation on the ISS as a way to bolster Russian counter proliferation efforts and adherence to the Missile Technology Control Regime (MTCR). As evidence for this interpretation, consider that in the summer of 1993 Washington did not want Moscow to sell cryogenic rocket engines and technological know-how to the Indians and that the $400 million initial US payment for Russian participation on the ISS corresponded exactly to the amount Moscow claimed it would lose by forgoing their contract with New Delhi. See Henry D. Sokolski, *Best of Intentions: America's Campaign Against Strategic Weapons Proliferation* (Westport: Praeger, 2001), 76-77.

On 8 February 1999, Space News editorialized that the United States' space launch ranges are "notorious for [their] lack of capacity, red tape and excessive turn-around time." Shortly thereafter, Lieutenant General Lance Lord, Vice Commander of AFSPC, responded by explaining the details of AFSPC's Range Standardization and Automation Modernization Plan (RSA). The RSA is a $1.2 billion comprehensive effort to create the world's best ranges by 2006. See Lieutenant General Lance Lord, "Range Modernization: The Rest of the Story," *Space News* (22 March 1999): 13. At the February 1999 AFA Convention, CINCSPACE General Richard B. Myers endorsed the recommendation for shared range management from Lieutenant General (retired) Richard Henry: "one obvious example of this process [divestiture] is the ranges. The Air Force owns our launch ranges, but maybe it's time to think about divestiture. In 1995, commercial launches just about matched DOD launches off the Eastern Range. Last year, commercial launches exceeded DOD launches on the East Coast. The trend in outyears is similar. Now I'm not talking about complete divestiture of launch operations – that would not be wise. But some version of shared management under a national spaceport concept, perhaps, where we retain the necessary level of military equity seems appropriate today. Lieutenant General (retired) Dick Henry's range I.P.T., with industry reaches similar conclusions, so we're giving his recommendations a serious, hard look, both at Air Force Space Command, and at the Air Staff."

According to NASA's ISS Website, the ISS is the "largest scientific and technical endeavor ever undertaken." Revision F (August 2000) of the ISS Assembly Sequence Planning Reference shows that 50 international launches between 1998-2006 will be

needed to assemble ISS components. Of course, as recent launch failures indicate, achieving 50 consecutive multinational launches on schedule and in sequence would be completely unprecedented in the history of space flight.

55 The National Space Transportation Policy, (5 August 1994).

56 Lockheed-Martin was the prime contractor for the X-33 and Orbital Sciences Corporation was the prime for the X-34. Both of these RLV programs ran into very significant technical and programmatic challenges, raising questions whether either system might replace the Space Shuttle or lead to an operational commercial variant. Anticipating increasing demand for launch vehicles, the Air Force is helping to provide funding for two EELV development programs rather than following the normal process of selecting a single system for development. The first government EELV payloads are scheduled for launch beginning in 2002. See William B. Scott, "EELV Funding: Is It Enough?" *Aviation Week & Space Technology* (1 March 1999): 27.

57 About $1.2 billion was spent on the X-33 program since it began in 1996 ($350 million from Lockheed Martin and $912 million from NASA). See Peter Pae, "Lockheed Asks Air Force to Fund X-33 Craft Revival," *Los Angeles Times* (14 April 2001); Frank Morring, "NASA Eyes Military Role in Aerospace Push," *Aviation Week & Space Technology* (23 April 2001): 36; and Brian Berger and Jeremy Singer, "USAF Plans Major Funding for A Space Plane by 2004," *Space News* (24 September 2001): 4.

58 The seven companies attempting to develop commercial RLVs are: Kelly Space and Technology, Kistler Aerospace Corporation, Pioneer Rocketplane, Rotary Rocket Company, Space Access LLC, Vela Technology Development, and Lockheed Martin Skunk Works. See McAlister, slide 7. In January 2001, officials from Kern County, Calif. threatened to seize Rotary Rocket assets and auction them off to pay property taxes owed by the company. "Rotary Rocket's Assets Seized," Associated Press (2 January 2001).

59 Headquarters Space and Missile System Center, Developmental Planning Directorate and Headquarters Air Force Space Command, Directorate for Plans and Programs, *Final Report: Commercial Space Opportunities Study* (Los Angeles AFB: Commercial Exploitation Planning Office, 16 February 2000). This study is known as the *Commercial Space Opportunities Study* or CSOS.

60 CSOS, ES-5, 3-2.

61 Estimating actual costs-per-pound-to-orbit for various launch vehicles is a cottage industry and such calculations are well beyond the scope of this chapter. Two outstanding recent discussions of basic problems with spacelift and current launch programs are Jim Oberg, *Space Power Theory,* 87-95 and Barry Watts, *The Military Use of Space,* 55-63.

62 CSOS, 3-2.

63 Ibid. 3-5.

64 Ibid. 3-4.

65 CSOS, 3-6, 3-9; and Lieutenant General Lance Lord, "Range Modernization: The Rest of the Story," *Space News* (22 March 1999): 13.

66 CSOS, 3-8.

67 A fact sheet and press release were issued on 10 March 1994. "Fact Sheet: Foreign Access to Remote Sensing Space Capabilities" (Washington DC: The White House, Office of the Press Secretary, 10 March 1994.

68 Fact Sheet: Foreign Access to Remote Sensing Space Capabilities, 10 March 1994. Brian Dailey and Edward McGaffigan provide a comprehensive look at PDD-23 in "US Commercial Satellite Export Control Policy: A Debate," in Henry Sokolski ed., *Fighting Proliferation: New Concerns for the Nineties* (Maxwell AFB: Air University Press, September 1996).

69 On the security implications of high-resolution commercial remote sensing see Yahya A. Dehqanzada and Ann M. Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World* (Washington DC: Carnegie Endowment for International Peace, 2000); Gerald M. Steinberg, "Dual Use Aspects of Commercial High-Resolution Imaging Satellites," Security and Policy Studies No. 37, (Bar-Ilan University, Israel: Begin-Sadat Center for Strategic Studies, February 1998); and Vipin Gupta, "New Satellite Images for Sale," *International Security* 20 (Summer 1995): 94-125.

70 CSOS, 3-13

71 Report of the National Commission for the Review of the National Reconnaissance Office, *The NRO at the Crossroads* (Washington DC: National Commission for the Review of the National Reconnaissance Office, 1 November 2000), quotations from pages 67, 74, and 71.

72 Report of the Independent Commission on the National Imagery and Mapping Agency, *The Information Edge: Imagery Intelligence and Geospatial Information in an Evolving National Security*

Environment (Washington DC: Independent Commission on the National Imagery and Mapping Agency, December 2000), quotations from pages viii, 60, and 33.

73 *The Information Edge,* 56.

74 Ibid. 16. On DOD's pledge to buy $1 billion worth of commercial imagery over the FYDP see, for example, Warren Ferster, "US to Buy Private Imagery for Intelligence," *Space News* (12 April 1999): 1 and 34.

75 *The Information Edge,* 89.

76 Ibid. 90.

77 Lt Gen Bruce Carlson, USAF, "Protecting Global Utilities: Safeguarding the Next Millennium's Space-Based Public Services," *Aerospace Power Journal* 14, no. 2 (Summer 2000): 37. For a more detailed discussion of why GPS does not fit exactly into existing categories of "natural monopoly," "public good," "utility, " or "dual-use technology" see Scott Pace et al., *The Global Positioning System: Assessing National Policies* (Washington DC: RAND Critical Technologies Institute, 1995), 184-89.

78 Carlson, "Protecting Global Utilities," 38.

79 Ibid. 37. Emphasis in original. The PanAmSat Corporation's *Galaxy 4* satellite failed on 19 May 1998.

80 See, for example, Brig Gen Simon Peter Worden, "The Air Force and Future Space Directions: Are We Good Stewards?" Aerospace Power Journal 15, no. 1 (Spring 2001): 50-57; and Carlson, "Protecting Global Utilities." For a more detailed development of this argument with a focus on distinctions between the role of armies and navies, see Brig Gen Simon P. Worden, "Space Control for the 21st Century: A Space 'Navy' Protecting the Basis of America's Wealth," in Peter L. Hays, James M. Smith, Alan R. Van Tassel, and Guy M. Walsh eds., *Spacepower for a New Millennium: Space and US National Security* (New York: McGraw-Hill, 2000), 240-41.

81 CSOS, 3-14. Sales of GPS equipment and services are expected to exceed $16 billion by 2003. See Stephen G. Moran, "GPS Policy: Past Accomplishments and Future Opportunities," *Institute of Navigation Newsletter* 8, no. 4 (Winter 1998-99).

82 DOD has provided all funding for the GPS. It has spent approximately $9.0 billion through 2001 and plans to spend about $9.4 billion on the system through 2016. These figures appear to include operations costs but not launch costs. United States General Accounting Office, "Defense Spectrum Management: More Analysis

Needed to Support Spectrum Use Decisions for the 1755-1850 MHz Band" (Washington DC: General Accounting Office, August 2001), 17.

83 Office of Science and Technology Policy and National Security Council, "Fact Sheet: US Global Positioning Policy," (Washington DC: The White House, 29 March 1996). USSPACECOM established the Navigation Warfare (Navwar) program to protect US and allied military GPS use within an area of operations, prevent enemy exploitation of GPS, and preserve civil GPS service outside military areas of operations.

84 The White House, Office of the Press Secretary, "Statement of the President Regarding the United States' Decision to Stop Degrading Global Positioning System Accuracy," 1 May 2000.

85 Presidential Decision to Stop Degrading Global Positioning System Accuracy.

86 A.J. Van Dierendonck and Chris Hegarty, "The New L5 Civil GPS Signal," *GPS World Online.*

87 The current and near-term inventory of GPS-enhanced PGMs includes the Conventionally Armed Air Launched Cruise Missile (CALCM), the Joint Air to Surface Standoff Missile (JASSM), the Joint Standoff Weapon (JSOW), and the Joint Direct Attack Munitions (JDAM). See John A. Tirpak, "Brilliant Weapons," *Air Force Magazine* 81 (February 1998). On GPS use in the Gulf War in 1991 and the Air War over Serbia in 1999, see Watts, "Military Use of Space," 41-46. In 1999, B-2 bombers using JDAMs and their GPS-aided targeting system were able to hit within approximately five meters of their intended target when bombing from 40,000 feet. In addition, JDAMs are relatively inexpensive for PGMs at less than $20,000 per round.

88 Mr. Keith R. Hall, "Presentation to the Committee on Armed Services Subcommittee on Strategic Forces," Washington DC: United States Senate, 8 March 2000.

89 "GPS & Selective Availability Q & A."

90 Michael Shaw, Kanwaljit Sandhoo, and David Turner, "Modernization of the Global Positioning System," *GPS World Online.* Finding and securing permission to use portions of the frequency spectrum requires extensive domestic and international coordination (with agencies such as the Federal Communications Commission and International Telecommunications Union).

91 Russia is marketing handheld GPS jammers with effective ranges of

80 and 192 kilometers. See Space Commission Report, 19-20; and Tom Wilson, "Threats to United States Space Capabilities," Paper Prepared for the Commission to Assess United States National Security Space Management and Organization.

92 The standard work on thinking about the unthinkable is Lawrence Friedman, *The Evolution of Nuclear Strategy* (New York: St. Martin's Press, 1983). John Newhouse, *Cold Dawn: The Story of SALT* (New York: Holt, Rinehart & Winston, 1973) describes MAD and the SALT I negotiations in detail.

93 The BMDO website shows $58.1 billion in SDIO and BMDO then year dollar authorizations from fiscal year 1985 to 2001.

94 Henry F. Cooper, "Active Defenses to Help Counter Proliferation," in Peter L. Hays, Vincent J. Jodoin, and Alan R. Van Tassel eds., *Countering the Proliferation and Use of Weapons of Mass Destruction* (New York: McGraw-Hill, 1998), 193-215. Ambassador Cooper was the last Director of SDIO.

95 Dennis Ward, "Helsinki, Demarcation, and the Prospects for US-Russian Accommodation on the Anti-Ballistic Missile Treaty," *Comparative Security* 16 (1997): 377-384. Ward was a BMDO representative at the SCC during the demarcation negotiations. In this article he argues that the demarcation agreement announced at Helsinki "fails at its only purpose– to draw a clear demarcation line that provides unambiguous guidance for compliance determinations" because there was never disagreement that the lower velocity interceptors were compliant but the demarcation agreement does not set a standard for testing compliance of higher velocity systems.

96 Ward, "Helsinki, Demarcation, and the Prospects," 380-81.

97 Jesse Helms (R-NC) was Chairman of the Senate Foreign Relations Committee and is leading opponent of the ABM Treaty. Helms argued that the Constitution requires submitting treaty protocols to the Senate for advice and consent prior to ratification. In May 1997, he made the requirement to submit the ABM Treaty protocols a legally binding precondition for ratification of the Conventional Forces in Europe Flank Document. The Clinton Administration missed Helms' deadline of 1 June 1999 for the administration to submit the ABM Treaty protocols to the Senate for approval. For its part, the Clinton Administration's Cologne Joint Statement with President Yeltsin called for the United States and Russia to move ahead on START III and ABM Treaty modification negotiations while continuing to link the ABM Treaty protocols (and several other arms control issues) to

ratification of START II by the Russian Duma. The US Senate provided its advice and consent to ratification of START II on 26 January 1996 and the Russian Duma ratified START II with conditions on 14 April 2000. The Clinton Administration had previously indicated that it would not submit the ABM Treaty protocols to the Senate until after the Duma ratified START II but it did not submit the protocols to the Senate prior to leaving office. See Jesse Helms, "Amend the ABM Treaty? No, Scrap It," *Wall Street Journal* (22 January 1999).

98 1998 appears to be a landmark year in terms of changing perceptions of the ballistic missile threat and the utility of missile defenses. At the risk of oversimplification, it is fair to characterize the beginning of the year as dominated by traditional thinking concerning the expense and difficulty of defense and the lack of a near-term threat. A continuing series of General Accounting Office (GAO) reports or the Welch Report's finding that BMDO was "rushing to failure" are representative of the first half of the year. Perceptions of the potential threat and proper response changed quite radically, however, following the Indian and Pakistani nuclear tests in May, the July 15 release of the Report of the Commission to Assess the Ballistic Missile Threat to the United States (usually referred to as the Rumsfeld Report after its chairman, former (and future) Secretary of Defense Donald H. Rumsfeld), the 22 July Iranian test of the Shahab-3 intermediate-range missile (developed with Russian, Chinese, and North Koran assistance), and the 31 August North Korean Taepo Dong I launch. According to Rumsfeld, the report found "an environment of little or no warning of ballistic missile threats to the United States from several emerging powers," a finding that was made to appear prescient by the Iranian and especially Korean launches only weeks later. The Rumsfeld Commission's charter was characterized as a "Team B" approach to reexamine the data that led to the December 1995 National Intelligence Estimate (NIE 95-19) finding that the continental United States would not be likely to face a ballistic missile threat until 2010. See Bill Gertz, "Missile Threats and Defenses," *Air Force Magazine* 81 (October 1998).

99 "Special Defense Department Briefing with Defense Secretary William Cohen," Federal News Service, 20 January 1999.

100 Bush's most comprehensive statement on the ABM Treaty and nuclear deterrence to date was his 1 May 2001 speech at National Defense University. Bush called for "a new framework that allows us

to build missile defenses to counter the different threats of today's world. To do so we must move beyond the constraints of the 30-year-old ABM Treaty. This treaty does not recognize the present or point us to the future. It enshrines the past." He also specifically linked together building defenses with offensive strategic nuclear force reductions as part of the new framework. Most significantly for our focus, President Bush noted some of the potential advantages of boost phase intercepts but carefully avoided even mentioning space-based BMD systems: "[Secretary Rumsfeld] has identified near-term options that could allow us to deploy an initial capability against limited threats. In some cases, we can draw on already established technologies that might involve land- based and sea-based capabilities to intercept missiles in mid-course or after they reenter the atmosphere. We also recognize the substantial advantages of intercepting missiles early in their flight, especially in the boost phase. The preliminary work has produced some promising options for advanced sensors and interceptors that may provide this capability. If based at sea or on aircraft, such approaches could provide limited but effective defenses." Presidents Bush and Putin met on 16 June in Slovenia on 22 July in Italy, and on 13-15 November 2001 in Washington and Crawford, Texas. At the November summit President Bush promised to cut the US nuclear arsenal by two-thirds, down to 1,700 to 2,200 warheads, in the next 10 years and President Putin pledged to make similar reductions in the total number of Russian warheads. According to the *New York Times,* National Security Advisor Condoleezza Rice summarized the outcome of the summit on the ABMT as follows: '"The President has made clear that one way or another the US will have to get out of the constraints of the missile defense treaty.' She set no deadlines and insisted that the relationship between the two men was so good that their differences over the treaty were less important than they were earlier this year. 'This is a smaller element of the US-Russia relationship than it was several months ago and certainly than it was before Sept. 11,' Ms. Rice said." David E. Sanger, "Before and After Bush and Putin's Banter, No Agreement on Missile Defense," *New York Times* (16 November 2001). For discussion on the rationale for US withdrawal from the ABMT, see also Jane Perlez, "Rice on Front Lines as Adviser to Bush," *New York Times,* 19 August 2001; and Patrick E. Tyler, "US Sets Deadline for Settlement of ABM Argument," *New York Times,* 22 August 2001. Both proponents and

opponents of BMD have invoked the 11 September 2001 terrorist attacks on the World Trade Center and the Pentagon to make their case. But in the wake of the attack, Democratic senators agreed to restore $1.3 billion in national missile defense funds that they had cut on 7 September from President Bush's $8.3 billion BMD budget request for fiscal year 2002.

101 "ABM Treaty Fact Sheet," (Washington DC: The White House, Office of the Press Secretary, 13 December 2001).

102 Thomas Duffy, "Missile Defense Overhaul Complete; BMDO Made a Defense Agency," *Inside the Army* (7 January 2002): 1.

103 In the 1980s the General Staff of the Soviet Union coined the term reconnaissance-strike complex and were among the first to recognize and discuss the possibility of an RMA enabled by enhanced surveillance and reconnaissance, miniaturization of electronic components, and precision guided munitions. See, in particular, the writings of former Chief of Staff Marshall Nikolai V. Ogarkov. The RMA is a major theme in the *Gulf War Air Power Survey* and is examined extensively by the survey's primary authors in Thomas A. Keaney and Eliot A. Cohen, *A Revolution in Warfare? Air Power in the Persian Gulf* (Annapolis: Naval Institute Press, 1995).

104 See, for example, the articles by Stephan Biddle, "Victory Misunderstood: What the Gulf War Tells Us about the Future of Conflict," *International Security* 21 (Fall 1996): 139-179; and "The Gulf War Debate *Redux:* Why Skill *and* Technology are the Right Answer," *International Security* 22 (Fall 1997): 163-174.

105 The term "system of systems" is associated with one of the strongest RMA advocates, Teledesic Corporation Co-Chief Executive Officer William A. Owens. Owens was formerly Vice Chairman of the Joint Chiefs of Staff. For Owens' explanation of this concept along with other articles that are strongly supportive of the RMA see Stuart E. Johnson and Martin C. Libicki eds., *Dominant Battlespace Knowledge: The Winning Edge* (Washington DC: National Defense University Press, 1995).

106 The Air Force' 1998 doctrine document places information warfare and information-in-warfare underneath the umbrella concepts of information operations and information superiority. "The emerging Air Force definition of information warfare is information operations conducted to defend one's own information and information systems or attacking and affecting an adversary's information and information systems. The defensive aspect, *defensive counter information, much*

like strategic air defense, is always operative. *Conversely,* the offensive aspect, *offensive counter information,* is primarily conducted during times of crisis or conflict. Information warfare involves such diverse activities as psychological operations, military deception, electronic warfare, both physical and information ("cyber") attack, and a variety of defensive activities and programs. It is important to stress that *information warfare* is a construct that operates across the spectrum, from peace to war, to allow the effective execution of Air Force responsibilities." Air Force Doctrine Document 2-5 *Information Operations* (Maxwell AFB: Air Force Doctrine Center, 5 August 1998), i-ii. Emphases in original.

107 Colin S. Gray and John B. Sheldon, "Spacepower and the Revolution in Military Affairs: A Glass Half Full," in Hays et al., *Spacepower for a New Millennium,* 240-41.

108 General Howell M. Estes III, Luncheon Address to Institute for National Security Studies "Spacepower for a New Millennium" Conference, USAF Academy, 30 July 1998.

109 *Global Engagement: A Vision for the 21st Century Air Force* (Washington DC: Department of the Air Force, November 1996), 8.

110 Advocating and developing robust force application systems would be one of the most obvious rationales for the Air Force to evolve into a space and air force but this is not even mentioned in *Global Engagement.*

111 General Michael E. Ryan and the Honorable F. Whitten Peters, *The Aerospace Force: Defending America in the 21st Century: A White Paper on Aerospace Integration* (Washington DC :Department of the Air Force, May 2000). General Michael E. Ryan and the Honorable F. Whitten Peters, *Global Vigilance, Reach & Power: America's Air Force Vision 2020* (Washington DC: Department of the Air Force, June 2000).

112 During 2000, national security space issues were carefully reviewed in three of the most important Congressionally mandated studies ever convened on this subject: The National Reconnaissance Office (NRO) Commission, the National Imagery and Mapping Agency (NIMA) Commission, and the Space Commission. *The NRO at the Crossroads* (Washington DC: National Commission for the review of the National Reconnaissance Office, 1 November 2000). *The Information Edge: Imagery Intelligence and Geospatial Information in an Evolving National Security Environment* (Washington DC: Independent Commission on the National Imagery and Mapping

Agency, December 2000), Space Commission Report.

The Space Commission Report is the broadest-ranging and most important product of the three commissions in 2000. The Space Commission was chaired by Donald Rumsfeld and included 12 other members with a broad-range of very high-level military space expertise. They are (listed with the top "space" job they formerly held): Duane Andrews (Deputy Undersecretary of Defense for Command, Control, Communications, and Intelligence); Robert Davis (Undersecretary of Defense for Space); Howell Estes (Commander, US Space Command); Ronald Fogleman (Air Force Chief of Staff); Jay Garner (Commander, Army Space and Strategic Defense Command); William Graham (President's Science Advisor); Charles Horner (Commander, US Space Command); David Jeremiah (Vice Chairman of Joint Chiefs of Staff); Thomas Moorman (Air Force Vice Chief of Staff); Douglass Necessary (House Armed Services Committee staff); Glenn Otis (Commander, Army Training and Doctrine Command); and Malcolm Wallop (Senator). See John A. Tirpak, "The Fight for Space," *Air Force Magazine* 83 (August 2000): 61.

The most important previous groups and their key space policy recommendations include: the 1954-55 Technological Capabilities Panel (TCP) (establish the legality of overflight and develop spy satellites); the President's Science Advisory Committee (PSAC) led by Science Advisor James Killian in 1958 (create the National Aeronautics and Space Administration (NASA); the SAMOS Panel led by Science Advisor George Kistiakowsky in 1960 (create the NRO); the review led by Vice President Lyndon Johnson in April 1961 (race the Soviets to the Moon for prestige); Vice President Spiro Agnew's 1969 Space Task Group (establish NASA's post-Apollo goals); the US Air Force's (USAF) 1988 Blue Ribbon Panel led by Maj Gen Robert Todd (integrate spacepower into combat operations); NASA's 1991 Augustine Commission (emphasize scientific exploration over shuttle operations); and the USAF's 1992 Blue Ribbon Panel led by Lt Gen Thomas Moorman (emphasize space support to the warfighter, establish the Space Warfare Center).

113 Space Commission Report, xxxi-xxxv.

114 Donald H. Rumsfeld, letter to Honorable John Warner, Chairman, Committee on Armed Services, United States Senate, 8 May 2001; Donald H. Rumsfeld, National Security Space Management and Organization Memorandum, Office of the Secretary of Defense, 18

October 2001.

CHAPTER 17. INTELLIGENCE SPACE PROGRAM

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2 Report of the Independent Commission on the National Imagery and Mapping Agency (NIMA).

3 There are a number of official histories of the National Reconnaissance Office (NRO), although none are very detailed concerning the formation of the organization. See, for instance: Gerald Haines, "The National Reconnaissance Office: Its Origins, Creation, and Early Years," in Dwayne A. Day, John M. Logsdon, and Brian Latell eds., *Eye in the Sky: The Story of the Spy Satellites* (Washington DC: Smithsonian Institution Press, 1998).

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CONCLUSION

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6 One rather pathetic footnote to this episode was the placing of advertisements in places like *The New York Times* soliciting innovative space exploration ideas.

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